Doctoral thesis submitted to
the Faculty of Behavioural and Cultural Studies
Heidelberg University
in partial fulfillment of the requirements of the degree of
Doctor of Philosophy (Dr. phil.)
in Psychology

Title of the publication-based thesis

Investigating a Phenomenon That Stands in Contrast to Evidence-Based Teaching: Educational Psychological Misconceptions Among Preservice Teachers

presented by
Cordelia Menz

year of submission
2021

Dean: Prof. Dr. Dirk Hagemann
Advisor: Dr. Eva Seifried

Acknowledgments

First and foremost, I would sincerely like to thank my advisor Dr. Eva Seifried for her extremely supportive and reliable feedback, her constant availability, and her emotional support throughout the different stages of this dissertation. I am also deeply grateful to Prof. Dr. Birgit Spinath for her valuable feedback on my research and for offering me such interesting working positions to help me develop and amplify my professional skills. In addition, I would sincerely like to thank Prof. Dr. Ingo Kollar for agreeing to act as a referee for my dissertation and for his encouraging feedback on my first presentation at an international scientific conference.

I gratefully acknowledge the financial support I received from the research project "Ask for Evidence – Vermittlung evidenzbasierten Denkens und Handelns in der Lehrerbildung" (Dr. Eva Seifried), funded by the RiSC program of the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg and by the Excellence Initiative of the German Federal Government and the state governments. I also want to thank Dr. Jane Zagorski for her proofreading.

Moreover, I would like to express my gratitude to all my colleagues for our constructive discussions and fun moments both in- and outside the office. Special thanks go to Eva Bosch, who is not only a very supportive and motivating colleague but who also became a very close friend. I also want to thank all my other friends who stood by my side throughout the last years, especially Andrea Kramer, who always offered me a sympathetic ear and her advice.

Finally, I am profoundly grateful for the best family I could ever wish for. I am particularly grateful to my supporting, loving, and encouraging parents Maria and Florian, my inspiring sister Mira, and my marvelous partner Jonas.

Summary

This dissertation was aimed at shedding light on one phenomenon that stands in contrast to evidence-based teaching (EBT): preservice teachers' educational psychological misconceptions. In order to achieve EBT, preservice teachers should endorse a small number of scientifically unsupported but often deeply ingrained assumptions (i.e., misconceptions), base their knowledge primarily on scientific instead of anecdotal evidence, and be able to accurately assess what they know and do not know (i.e., metacognitive monitoring accuracy). Gaining deeper insight into the prevalence and sources of as well as a reduction in educational psychological misconceptions offers the chance to support preservice teachers in overcoming their misconceptions and thus enables preservice teachers to become teachers who act in accordance with calls for EBT.

This dissertation presents findings about psychological misconceptions, why they should be combatted, where they come from, and how to reduce them in order to foster EBT. In Paper 1, we compared the prevalence of educational psychological misconceptions with the prevalence of general scientific misconceptions. In addition, we investigated whether preservice teachers were more likely to change their educational psychological misconceptions after reading short empirical or anecdotal refutation texts. In Paper 2, we explored the prevalence of further misconceptions and their origins. Building on the differentiation between scientific and anecdotal information, we were interested in the sources that preservice teachers use to form their beliefs and whether relying more on anecdotal information was associated with attributes that stand in contrast to EBT (e.g., endorsing more misconceptions). In Paper 3, we investigated different approaches that could be applied to reduce educational psychological misconceptions and enhance metacognitive monitoring accuracy (persistently) in real-life settings (i.e., standard lectures, refutation lectures, instruction in information evaluation strategies). I discuss the presented findings critically with regard to EBT and outline practical implications as well as open questions for further research.

List of Papers Included in the Publication-Based Dissertation

Paper 1

Menz, Cordelia, Spinath, Birgit, & Seifried, Eva (2020). Misconceptions Die Hard: Prevalence and Reduction of Wrong Beliefs in Topics From Educational Psychology Among Preservice Teachers. *European Journal of Psychology of Education.* Advance online publication. https://doi.org/10.1007/s10212-020-00474-5

Paper 2

Menz, Cordelia, Spinath, Birgit, & Seifried, Eva (2021). Where Do Pre-Service Teachers' Educational Psychological Misconceptions Come From? The Roles of Anecdotal Versus Scientific Evidence. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000299

Paper 3

Menz, Cordelia, Spinath, Birgit, Hendriks, Friederike, & Seifried, Eva (in press). Reducing Educational Psychological Misconceptions: How Effective Are Standard Lectures, Refutation Lectures, and Instruction in Information Evaluation Strategies? *Scholarship of Teaching and Learning in Psychology*.

Publication that is closely related to the dissertation's topic:

Hendriks, Friederike, Seifried, Eva, & Menz, Cordelia (2021). Unraveling the "Smart but Evil" Stereotype: Pre-Service Teachers' Evaluations of Educational Psychology Researchers Versus Teachers as Sources of Information. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000300

Contents

1. Introduction

In recent years, the term *post-truth* has gained more and more attention, and it has been argued that we live in a post-truth era (e.g., Laybats & Tredinnick, 2016; Lewandowsky et al., 2017; Sismondo, 2017). Post-truth is defined as "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (Oxford English Dictionary, n.d.), and this term was elected word of the year in 2016 (Flood, 2016). The rise of the post-truth era is commonly associated with politics and the media (see, e.g., Laybats & Tredinnick, 2016; Lockie, 2017; Peters, 2017; Sismondo, 2017), but in order to overcome it, education can play a leading role (see, e.g., Barzilai & Chinn, 2020). For instance, focusing on evidence-based practice in education could be one way to diminish the influence of post-truth on both teachers and their students. Also, researchers can counteract post-truth and belief in "fake news" through, for example, questioning prevalent assumptions (see Feinstein & Waddington, 2020). In the psychological context, such assumptions that are questionable, popular, and widespread but not in line with current scientific findings have been defined as psychological misconceptions (see Bensley & Lilienfeld, 2015). Counteracting post-truth among (preservice) teachers[1] is especially important because they act as role models (see Commission of the European Communities, 2007), are distributors of knowledge, and have a strong influence on different people—among other things but above all on their (future) students. As such, counteracting (preservice) teachers' incorrect assumptions about topics that are important for their professional lives (i.e., educational psychological misconceptions) may have additional positive down-stream consequences as it can help to reduce misconceptions in students as well. Different trends and factors have been discussed as being associated with both post-truth in general and beliefs in psychological misconceptions in particular, including a reliance on personal experiences instead of evidence (see, e.g., Barzilai & Chinn, 2020; Hughes,

[1]In the following, *(preservice) teachers* refers to both preservice teachers and practicing teachers. When only one group is addressed, they are identified as either *preservice teachers* or *teachers*.

Lyddy, & Lambe, 2013; Taylor & Kowalski, 2004). Holding misconceptions and basing one's decisions more on emotion or personal beliefs and experiences instead of facts stands in contrast to evidence-based practice. In the specific case of (preservice) teachers and the educational context, endorsing educational psychological misconceptions and basing one's knowledge and decisions on personal experiences hinders evidence-based teaching (EBT), possibly reducing the quality of education (see Ferrero et al., 2020).

This dissertation focuses on preservice teachers' educational psychological misconceptions as a specific phenomenon that contradicts EBT. I begin with a general chapter about (the importance of) EBT and a key challenge regarding the implementation of it: (preservice) teachers' preference for anecdotal information. Closely related, I briefly describe the research project "Ask for Evidence" (project leader: Dr. Eva Seifried) in which my dissertation was implemented. Afterwards, I focus on misconceptions as a specific hindering aspect of EBT that needs to be investigated by describing psychological misconceptions in general as well as their origins and possible approaches to reduce them. I use these chapters to outline the open research questions that led to this dissertation, followed by the three empirical studies that were conducted to gain deeper insight into German preservice teachers' educational psychological misconceptions: First, we chose four possible educational psychological misconceptions and investigated their absolute as well as their relative prevalence among preservice teachers in Germany. In addition, we analyzed whether anecdotal or scientific refutation texts have the effect of reducing misconception endorsement (Paper 1: Menz et al., 2020). Second, we considered a broader range of possible educational psychological misconceptions by using 14 new topics, explored the origins of these misconceptions, and examined whether basing one's beliefs more on anecdotal than scientific evidence is associated with undesirable aspects (Paper 2: Menz et al., 2021). Third, we used a real-life setting to determine how preservice teachers' educational psychological misconceptions can be reduced and how their knowledge about what they know and what they do not know (i.e., metacognitive

monitoring accuracy) can be enhanced. We examined both misconceptions and metacognitive monitoring accuracy with respect to 18 educational psychological topics in three different conditions (i.e., a standard lecture, a refutation lecture, and a group receiving instruction in information evaluation strategies) over the duration of one semester and with a follow-up survey half a year later (Paper 3: Menz et al., in press). In the last section of this dissertation, I generally discuss these findings, including strengths and limitations, as well as open research questions and practical implications in the field of educational psychological misconceptions among preservice teachers.

2. Evidence-Based Practice

In general, evidence-based practice can be defined as considering scientific findings and reliable theories for professional acting (see Bauer et al., 2015; Trempler et al., 2015). Calls for evidence-based practice have a long tradition in different fields, for example, medicine (see Rosenberg & Sackett, 1996) or nursing (see Profetto-McGrath, 2005). Regarding the field of education, Davies (1999) analogously introduced the idea of evidence-based education. According to Davies, evidence-based education comprises two important aspects: (a) using (i.e., finding and interpreting) evidence, and (b) establishing evidence (i.e., conducting thorough research). In the educational context, different terminologies are used to refer to the overarching idea of evidence-based education, for example, evidence-based practice (e.g., Biesta, 2007), evidence-oriented practice (e.g., Stark, 2017), evidence-informed practice (e.g., Nelson & Campbell, 2017), research-informed practice (e.g., Lingard & Renshaw, 2010), or evidence-based teaching (e.g., Dunn et al., 2013). Throughout this dissertation, I consistently use the term evidence-based teaching (EBT) because it includes one key task of (preservice) teachers, that is, teaching.

2.1 The Importance of and how to Achieve EBT

Evidence-based teaching refers to the choice and application of learning techniques and tools that have empirical support for their effectiveness (see, e.g., Saville, 2010; Schwartz & Gurung, 2012). Practice testing (see, e.g., McDaniel et al., 2007, 2012; Roediger et al., 2011) or spaced learning/distributed practice (see, e.g., Delaney et al., 2010; Rohrer & Taylor, 2006) are examples of such effective teaching and learning strategies that could be implemented in EBT (see Dunn et al., 2013; Dutke et al., 2017; for a review of effective learning techniques, see also Dunlosky et al., 2013). This use of various effective teaching and learning techniques or tools can also foster one specific and important skill that needs to be achieved through education: metacognition (Dunn et al., 2013). Metacognition, or in other words, students' ability to evaluate what they know and what they do not know, influences the direction of future learning (Händel et al., 2020) and might also play an essential role in the formation and possible debunking of misconceptions (see Bensley & Lilienfeld, 2017; Pieschl et al., 2019). Hence, the general idea of fostering EBT is an improvement in teaching and learning both in- and outside the classroom (see Cranney, 2013; Dunn et al., 2013; Groccia & Buskist, 2011), including fostering metacognition (Dunn et al., 2013).

Besides various researchers calling for EBT (e.g., Bauer et al., 2015; Cranney, 2013; Dunn et al., 2013; Dutke et al., 2017; Groccia & Buskist, 2011; Slavin, 2002), standards for teacher education also include requirements to foster EBT (e.g., Commission of the European Communities, 2007). In Germany, the Kultusministerkonferenz (KMK, 2004) states that teachers need to use scientific findings from the educational context for their own practice. On the European level, the Commission of the European Communities (2007) also requires teachers to conduct research in their classrooms and to include research findings in their teaching. Outside Europe, the American National Board for Professional Teaching Standards (NBPTS, 2016) states that "teachers also stay abreast of current research and, when appropriate,

incorporate new findings into their practice" (p. 32). Taken together, teachers are supposed to base their teaching and learning processes on scientific findings (Bauer & Prenzel, 2012; Borg, 2010; Commission of the European Communities, 2007; KMK, 2004). One stage in teachers' lives in which they are repeatedly confronted with current scientific findings is during their teacher training at university: Teacher education programs in Europe have become more research-based due to the Bologna Process (see Bauer & Prenzel, 2012). However, the moment preservice teachers leave teacher education and enter their professional lives, it becomes challenging to draw their attention to research findings (see Hartmann et al., 2016). Therefore, the beginning of teacher training at university should ideally constitute the time and place to foster a positive attitude toward research and to enable an evidence-based mindset in (preservice) teachers (see, e.g., Csanadi et al., 2021; Kiemer & Kollar, 2021; Scheeler et al., 2016; van der Linden et al., 2012), especially because a positive view of research information has been shown to be a predictor of its use (e.g., Lysenko et al., 2014). Educational psychology, a discipline that is included in many teacher training programs (see, e.g., Dutke et al., 2016; Patrick et al., 2011; Spinath et al., 2018) could play a specific role in doing so: Especially university lecturers in psychology classes could be role models for implementing EBT because they can build their teaching practice on research knowledge from the academic field they are working in (see, e.g., Dunn et al., 2013; Dutke et al., 2017).

Besides a positive attitude toward research findings (see, e.g., Lysenko et al., 2014; van Schaik et al., 2018), specific skills are also important to enable (preservice) teachers and render them more likely to use evidence during the course of their studies and later in their professional lives (see Davies, 1999). To support (preservice) teachers in using evidence, different programs have been created. In Germany, for instance, *Evidence for Teachers (E4teach)* focuses on developing two facets of evidence-based practice, namely, the evaluation of evidence and the argumentative use of evidence (Wenglein et al., 2015). Moreover, synthesizing interpretable and scientifically valid research is the foundation of EBT (Slavin, 2008), and this purpose is

followed by the *What Works Clearinghouse* (WWC; see https://ies.ed.gov/ncee/wwc/) and others (e.g., BEE, CSRQ, C2, EPPI-Centre; for more information, see Slavin, 2008). For example, the WWC also covers the widespread misconception about the effectiveness of different learning styles (U.S. Department of Education, 2014), thus fostering an engagement with and debunking of misconceptions from the educational context. Another approach that links to the proclaimed aspect of "establishing" by Davies (1999) is supporting preservice teachers at university to conduct research and engage as researchers (see, e.g., Afdal & Spernes, 2018; Brew & Saunders, 2020; Niemi & Nevgi, 2014; Organisation for Economic Development, 2005). It has been argued that this approach enables prospective teachers to implement research in their practice (see Afdal & Spernes, 2018; Baan et al., 2019; Organisation for Economic Development, 2005) and to step back from their experience-based beliefs about teaching (Kagan, 1992). In addition, engaging preservice teachers as researchers helps them identify the elements that are required for conducting sound empirical research (see Afdal & Spernes, 2018), and this could in turn buffer them against endorsing misconceptions from the educational context (e.g., preventing them from regarding research about the effectiveness of learning styles as sound even though it is flawed, see, e.g., Pashler et al., 2008).

In sum, teachers are required to use and establish research findings to improve teaching and learning (e.g., Commission of the European Communities, 2007; Dunn et al., 2013; KMK, 2004). Various approaches that support (preservice) teachers in achieving these requirements have been developed and investigated (e.g., Fischer et al., 2014; Klein et al., 2015; van Ingen & Ariew, 2015; Wenglein et al., 2015; What Works Clearinghouse, 2020; see also Slavin, 2008). Nevertheless, review articles have indicated that many teachers still seldom use scientific research findings to inform and design their practice (e.g., Cain, 2016; Dagenais et al., 2012), indicating a gap between research and practice (see, e.g., Broekkamp & van Hout-Wolters,

2007; Emmons et al., 2009; Korthagen, 2007; McIntyre, 2005; Vanderlinde & van Braak, 2010), or put differently, a gap between requirement and reality.

2.2 A Challenge for EBT: (Preservice) Teachers' Preference for Anecdotal Information

One reason why the aforementioned gap between research and practice exists might be that (preservice) teachers devalue research information and have a preference for anecdotal information (see, e.g., Hargreaves, 2000). Empirical research has shown that preservice teachers ascribe (pedagogical) theory "little value for the classroom" (Sjølie, 2014, p. 738) and that they disparage the theories they learned during teacher education (Allen, 2009). Labaree (2003) argued that researchers can provide as much data as they want but that personal experience will still be more important for teachers. Accordingly, a qualitative investigation showed that preservice teachers considered teachers' experiences to be more important than research when making decisions in the classroom (Gitlin et al., 1999). There are several studies that have indicated that (preservice) teachers have a general preference for unsystematic (e.g., common sense, experience-based knowledge, intuition, personal experiences) instead of systematic (e.g., evidence-based/theory-based knowledge, data, scientific information) sources of information (e.g., Bråten & Ferguson, 2015; Clark, 1988; Costa et al., 2000; Kiemer & Kollar, 2021; Landrum et al., 2007; Nelson & Campbell, 2017; Parr & Timperley, 2008; Schildkamp & Kuiper, 2010; Williams & Coles, 2007). For example, Bråten and Ferguson (2015) asked preservice teachers to rate different kinds of sources about specific educational psychological topics regarding their significance as sources of knowledge. Results indicated that preservice teachers preferred experiential sources (e.g., personal experience, observing other teachers) over formalized sources (e.g., research articles, textbooks). In addition, this investigation showed that preservice teachers have a preference for practical over theoretical learning tasks. In another study, Williams and Coles (2007) found that teachers predominantly named "talking to teacher colleagues" as a source when searching for new information.

Discussions with other teachers were even named the most when teachers were specifically asked which sources they would consult to find research information. These findings are in accordance with a study that showed that teachers ascribe lower trustworthiness and usability to research information compared with other colleagues or workshops (Landrum et al., 2002). Another study asked teachers to rate the validity of 12 pedagogical statements (covering, e.g., motivation, group work, discovery learning). In addition, teachers indicated the knowledge base on which they rated the validity. Results showed that personal experience played the major role (51.9%) as knowledge base, and common sense (13.4%) was also mentioned more often than scientific studies (9.3%) in this study (Costa et al., 2000). Accordingly, Buehl and Fives (2009) found that (preservice) teachers often named informal sources (e.g., personal experience, observations of other teachers) when asked about where their knowledge of how to teach comes from. Besides the low preference or use of scientific information for (intended) decisions and knowledge acquisition, a German study also revealed a low use of scientific educational findings among teachers who plan their classes (Hetmanek et al., 2015), thus also contradicting EBT. Perhaps educational research is seldom used because it is perceived as "too soft, squishy, unreliable, and imprecise to rely on as a basis for practice" (Berliner, 2002, p. 18). In fact, different authors have claimed that educational research is perceived as not being applicable to classroom practice or as not addressing questions of practical relevance (e.g., Vanderlinde & van Braak, 2010, see also the review by van Schaik et al., 2018).

Even though there is ample evidence that (preservice) teachers prefer anecdotal evidence over scientific evidence as their knowledge base and for their decision making (e.g., Bråten & Ferguson, 2015; Costa et al., 2000; Williams & Coles, 2007), some studies have indicated a different pattern (e.g., Ingram et al., 2004; Merk et al., 2017). For example, one study showed that teachers base their decisions equivalently on data and personal experience (Ingram et al., 2004). In addition, more than two thirds of a teacher sample in another study indicated that educational research findings had a positive influence on their development in

becoming teachers, and the majority of this sample considered teaching to be a research-based profession (Pendry & Husbands, 2000). In another study, Merk et al. (2017) found that, contrary to their hypothesis, preservice teachers rated pedagogical knowledge as more practically valuable when it originated from scientific studies compared with when it originated from a practitioner or an expert. Recently, it has been argued that preservice teachers perceive researchers as "smart but evil" with respect to their trustworthiness, that is, more competent but less benevolent and with less integrity than practitioners (Merk & Rosman, 2019). Moreover, in a current study, we found that preservice teachers adapted their ratings of this trustworthiness for different epistemic aims: When looking for theoretical explanations, researchers were ascribed more expertise and integrity compared with teachers; however, when looking for practical advice, teachers were ascribed more expertise, integrity, and benevolence than researchers (Hendriks et al., 2021). To sum up so far, the majority of previous research has indicated a preference for anecdotal over scientific information among (preservice) teachers (e.g., Bråten & Ferguson, 2015; Costa et al., 2000; Williams & Coles, 2007), and this preference stands in contrast to EBT. Moreover, this reliance on unsystematic information can also foster misconceptions (see Lilienfeld et al., 2012) because misconceptions are often based on commonsense assumptions but are contradicted by scientific research (see Bensley & Lilienfeld, 2015). Therefore, preferring anecdotal information over scientific evidence challenges the educational system on a general level by hindering EBT but also on a more specific level by making (preservice) teachers prone to holding misconceptions about topics from the educational context, which in turn also stands in contrast to EBT (see Ferrero et al., 2020).

Although several authors have called for EBT, and different standards for teacher education have emphasized the importance of using research to inform teachers' practice (see, e.g., Commission of the European Communities, 2007; Groccia & Buskist, 2011; KMK, 2004; Slavin, 2002, 2008), it is clear that teachers should not act as robots whose actions in the

classroom are based only on research findings. It has been argued that "evidence-based practice is not 'cook book' teaching (. . .). It is about integrating professional expertise with the best external evidence from research to improve the quality of practice" (Sharples, 2013, p. 7). This idea is also reflected in the argumentation by Bauer et al. (2015) when they stated that research-based evidence cannot and should not replace individual expertise and experience but should rather operate as guidance to achieve an improvement in one's professional actions and as a rationale for decisions. Also the NBPTS (2016) emphasized the importance of professional experience alongside educational research information regarding teachers' professional acting. As a result, professional personal experience should not be excluded from the teaching profession; however, the shortcomings of primarily relying on personal experience (e.g., suffering from cognitive biases, nonsystematic data, small sample sizes; see, e.g., Lilienfeld et al., 2012) in contrast to research information (e.g., high-quality methods, independence of researchers, supervision through peer review; see, e.g., Bromme et al., 2014) have to be considered critically, especially because a reliance on experience-based and potentially biased information can lead to misconceptions (see Gilovich, 1991).

Taken together, previous research has indicated a strong preference for anecdotal over scientific information among (preservice) teachers (e.g., Bråten & Ferguson, 2015; Costa et al., 2000; Nelson & Campbell, 2017; Williams & Coles, 2007), and research findings have seldom been used to inform teachers' practice (e.g., Dagenais et al., 2012; Hetmanek et al., 2015; Lysenko et al., 2014). Hence, even though teachers should not use only scientific research (see, e.g., Bauer et al., 2015) to inform their practice, a strong or extensive reliance on anecdotal evidence—particularly in the case of anecdotal evidence that contradicts scientific evidence—in combination with a devaluing of research still contradicts the idea of EBT and makes (preservice) teachers more likely to endorse misconceptions.

3. Research Project "Ask for Evidence"

To shed more light on preservice teachers' evidence-based thinking and acting, Dr. Eva Seifried obtained funding for the research project "Ask for Evidence" by the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg and by the Excellence Initiative of the German Federal Government and the state governments—Funding line Institutional Strategy (Zukunftskonzept). To counteract a post-truth society, this project was dedicated to investigating the current state of preservice teachers' evidence-based thinking and acting. With this project, we developed a new questionnaire to measure different aspects of preservice teachers' perceptions of scientific findings from different disciplines, considered cultural differences and possible reasons regarding a devaluing of scientific findings from (educational) psychology among preservice teachers, and investigated attempts to improve preservice teachers' valuing of scientific findings from educational psychology. In addition, we conducted research on whether preservice teachers ascribe different degrees of epistemic trustworthiness (i.e., expertise, integrity, benevolence) to teachers or educational psychology researchers, depending on the epistemic aims preservice teachers are pursuing (Hendriks et al., 2021).

In short, the research project in which my dissertation was embedded concentrated on the status quo of preservice teachers' negative attitudes toward scientific findings from (educational) psychology, the reasons for this devaluing, and methods for fostering EBT on a general level. Within the framework of the project, I specifically focused on educational psychological misconceptions. First, I investigated the prevalence of various educational psychological misconceptions among preservice teachers; second, I examined possible sources of these misconceptions; and finally, as it is of utmost importance to combat misconceptions and foster metacognition, I evaluated methods for reducing educational psychological misconceptions and enhancing metacognitive monitoring in order to implement EBT among preservice teachers. As such, the present work contributes to the overarching project goals of investigating and fostering preservice teachers' evidence-based thinking and acting. However,

it constitutes an independent thread by focusing on educational psychological misconceptions as one specific phenomenon that contradicts EBT.

4. Misconceptions

Misconceptions, commonly defined as "a belief that conflicts with currently accepted scientific explanations" (Tippett, 2010, p. 953), can be found in various disciplines. For example, in biology, misconceptions regarding natural selection (Nehm & Reilly, 2007) or evolution (Vaughn & Robbins, 2017) can be found, and in physics, misconceptions regarding force (Hestenes et al., 1992) exist. Such discipline-related misconceptions have been widely investigated among (preservice) teachers regarding topics from the subjects they (are going to) teach (e.g., Bayraktar, 2009; Butler et al., 2015; Kaltakci-Gurel et al., 2016; Ryan & McCrae, 2006; Stein et al., 2008; Yates & Marek, 2014; see also the review by Francek, 2013). There are also many international studies on (preservice) teachers' misconceptions about learning and the brain, indicating a high prevalence of beliefs in so-called neuromyths (e.g., Blanchette Sarrasin et al., 2019; Dekker et al., 2012; Dündar & Gündüz, 2016; Ferrero et al., 2016; Gleichgerrcht et al., 2015; Grospietsch & Mayer, 2018; Hermida et al., 2016; Krammer et al., 2019; Lethaby & Harries, 2016; Macdonald et al., 2017; Papadatou-Pastou et al., 2017; Pei et al., 2015; Rato et al., 2013; Tardif et al., 2015; Tovazzi et al., 2020). However, other misconceptions that have the potential to impair teaching (i.e., educational psychological misconceptions) have not been investigated in detail among (preservice) teachers. Such misconceptions that are based on flawed mental models or incorrect beliefs about topics from educational psychology stand in direct contrast to EBT when applied to (preservice) teachers' professional contexts (see Ferrero et al., 2020) because misconceptions, by definition, contradict findings from scientific research. In the following, I define psychological misconceptions, present current information regarding their prevalence among different groups, introduce different sources that are relevant for the formation of such misconceptions, and

describe a promising way to reduce misconceptions as well as the shortcomings of this approach.

4.1 Definition and Prevalence of Psychological Misconceptions

There are different definitions of psychological misconceptions. Some definitions in psychology research refer to "inaccurate prior knowledge" (Taylor & Kowalski, 2014, p. 259), whereas other authors use the description of "false, common-sense beliefs" (Bensley & Lilienfeld, 2015, p. 283) or define psychological misconceptions as "claims about behavior and mental processes that are unsupported or contradicted by high-quality psychological research" (Bensley & Lilienfeld, 2017, p. 378). Thus, psychological misconceptions can be defined as knowledge, beliefs, or claims that are contradictory to results from psychological research (for the difficulty of disentangling knowledge and beliefs, see, e.g., Pajares, 1992). Psychological misconceptions have been studied for decades (e.g., Bensley & Lilienfeld, 2015; Gutman, 1979; Hughes et al., 2015; McCutcheon et al., 1992; Taylor & Kowalski, 2004; Vaughan, 1977). These studies have mostly focused on the general public and psychology students with different levels of experience in psychology, ranging from introductory psychology classes to psychology majors (Bensley & Lilienfeld, 2015; Bensley et al., 2014, 2015; Furnham, 2018; Furnham et al., 2003; Furnham & Hughes, 2014; Gaze, 2014; Glass et al., 2008; Hughes, Lyddy, & Kaplan, 2013; Kowalski & Taylor, 2004, 2009, 2017; Kuhle et al., 2009; LaCaille et al., 2019; Lyddy & Hughes, 2012; McCarthy & Frantz, 2016; Sciutto, 2015; Sibicky et al., 2020; Taylor & Kowalski, 2004, 2012). Various psychological misconceptions have been found to be highly prevalent among these groups: For example, Bensley and Lilienfeld (2015) found prevalence rates of above 50% for nearly half of their 40 investigated topics. Highly prevalent misconceptions from this study included the misconception about learning styles (i.e., teaching styles and learning styles should be matched to achieve better learning), the belief in the first instinct fallacy (i.e., on multiple choice tests, it is best to stick with your first choice), or the

assumption that academic achievements can be improved by raising one's self-esteem. These psychological misconceptions are only a small subset of possible psychological misconceptions from different psychological subdomains—further potential psychological misconceptions can be found in the book *50 Great Myths of Popular Psychology* by Lilienfeld et al. (2010).

In addition to the prevalence of psychological misconceptions, it has also been shown that individuals are often overconfident regarding their (supposed) knowledge, including psychological misconceptions (e.g., Bensley et al., 2015; Dunning, 2011; Landau & Bavaria, 2003). This overconfidence in misconceptions means that people not only hold beliefs that are not in accordance with current scientific findings but are also mistakenly confident that their beliefs are accurate. For instance, overconfidence is indicated by holding the incorrect belief that matching teaching with different learning styles has a positive influence on learning, and in addition, being convinced that this belief is definitely true. Thus, overconfidence in misconceptions indicates a low level of metacognitive monitoring accuracy, that is, a discrepancy between knowledge and confidence in this knowledge (see Barenberg & Dutke, 2013). It is said that such metacognitive ability can play a critical role in identifying misconceptions (see Bensley & Lilienfeld, 2015, 2017), for example, by enabling someone to reflect on their knowledge and identify blind spots. Within the aforementioned example, realizing that one does not possess enough information regarding the effectiveness of matching teaching to learning could lead them to rethink their knowledge and become less confident in it. Consequently, enhancing one's metacognitive monitoring accuracy or, in other words, supporting someone in being able to accurately assess what they know or do not know should lead to fewer misconceptions or, at least, to endorsing misconceptions with less confidence.

As mentioned above, besides general psychological misconceptions, there are also psychological misconceptions regarding the educational context (see de Bruyckere et al., 2015). One of these educational psychological misconceptions that has achieved enormous attention

is the misconception about the effectiveness of different learning styles, covered as either a psychological misconception (see, e.g., Bensley & Lilienfeld, 2015; Taylor & Kowalski, 2012) or a neuromyth (e.g., Dekker et al., 2012; Dündar & Gündüz, 2016; Grospietsch & Mayer, 2018; Hermida et al., 2016; Papadatou-Pastou et al., 2017; Pei et al., 2015; Rato et al., 2013; Tardif et al., 2015). However, knowledge about other impairing psychological misconceptions in the educational context among (preservice) teachers is still scarce. This knowledge needs to be expanded because teachers act as role models (Commission of the European Communities, 2007) and have an influence on different people (e.g., students, parents of their students, colleagues) and different tasks (e.g., design of classroom activities, design of curricula) in the educational context, thus rendering (preservice) teachers multipliers of—ideally sound—knowledge. Identifying prevalent educational psychological misconceptions next to the learning styles misconception therefore constitutes an important first step in preventing (preservice) teachers from acting on the basis of or distributing incorrect beliefs in the educational context and thereby supporting them to engage in EBT.

4.2 Sources of Psychological Misconceptions

Lewandowsky et al. (2012) identified various origins that contribute to the formation of misconceptions in general: rumors and fiction, governments and politicians, vested interests, and the media (for fictional sources, see also Fazio et al., 2015). Also regarding psychological misconceptions, there are different sources that might play a role in their development and adherence. In the literature, the media is frequently named as an important stage for the perpetuation of psychological myths (e.g., Bensley & Lilienfeld, 2017; Chew, 2006; Gardner & Dalsing, 1986; Lilienfeld, 2005; Sciutto, 2015; Taylor & Kowalski, 2004). Lilienfeld (2005) argued that misconceptions are nourished through oversimplified presentations of information on the Internet and in the media, and Taylor and Kowalski (2004) supported this claim empirically: They asked introductory psychology students what sources they attributed their

knowledge acquisition to. For the students' misconceptions, they found "media" to be named second most often (20%) after "I do not know" (30%) and directly followed by "personal experience" (19%). These percentages point to another frequently mentioned source of psychological misconceptions: personal experience.

The importance of personal experience as a source of misconceptions can be certified by further empirical studies. For example, when Gaze (2014) asked students to indicate their source of knowledge acquisition for one self-selected item from a misconception test, 30% of the introductory psychology student sample named "personal experience". From a theoretical point of view, personal experience is likely to be the source of misconceptions due to different cognitive biases (see Chew, 2006; Gilovich, 1991). In the specific case of (preservice) teachers, it is reasonable to assume that personal experience plays an especially important role in the formation of psychological misconceptions. First, and as outlined above, (preservice) teachers prefer anecdotal evidence (e.g., Bråten & Ferguson, 2015; Costa et al., 2000). Second, each and every (preservice) teacher has their own history of school experiences, including their experiences as students (see Stuart & Thurlow, 2000) and as (student) teachers, thus increasing the possibility that lively anecdotal evidence will come from the educational system. However, anecdotal evidence is not always in accordance with empirical evidence and might be biased (see, e.g., Lilienfeld et al., 2012), thus potentially leading to misconceptions.

Besides "media" and "personal experience", other frequently mentioned potential sources of psychological misconceptions are "common sense" (e.g., Hughes, Lyddy, & Lambe, 2013; Lilienfeld, 2010; Lyddy & Hughes, 2012), "narratives from other people" or "personal contact" (e.g., Bensley & Lilienfeld, 2017; Gardner & Dalsing, 1986; Landau & Bavaria, 2003), "lectures" or "education" (e.g., Chew, 2006; Hughes et al., 2015; Hughes, Lyddy, & Lambe, 2013; Landau & Bavaria, 2003; Taylor & Kowalski, 2004), and "publications" (e.g., Higbee & Clay, 1998; Lilienfeld, 2010). From this list, the scientific categories in particular (i.e., lectures,

publications) might seem surprising, but in a study by Higbee and Clay (1998), 12% of the psychology majors who were investigated indeed named a publication, a specific class, or a program when they were asked to indicate the source of their answer to the question about the percentage of brain power most people use. Nevertheless, it has been argued that psychological misconceptions are particularly likely to be built on informal sources (see, e.g., Bensley & Lilienfeld, 2015).

It is important to take critical note of the fact that most of the literature either assumes what the sources of misconceptions are (e.g., Lilienfeld, 2005; Lyddy & Hughes, 2012) or relies on self-report measures (e.g., Gaze, 2014; Higbee & Clay, 1998; Taylor & Kowalski, 2004). In addition, many participants fail to remember the sources of their misconceptions (e.g., Taylor & Kowalski, 2004). It has been argued that knowing the sources of misconceptions can help instructors to address and combat those misconceptions (see, e.g., Brinthaupt et al., 2016); however, most research has relied on only perceived sources but has not verified whether the perceived source is also the real source of the respective misconception (e.g., Brinthaupt et al., 2016; Gaze, 2014; Landau & Bavaria, 2003; Taylor & Kowalski, 2004). Most likely, knowing the perceived sources is as important as knowing the real sources in order to counteract misconceptions because where people *believe* they got their knowledge also matters. For example, Landau and Bavaria (2003) found that psychology students mostly attributed their misconceptions to psychology-related information, for example, their psychology instructor. In this aspect, it might not matter whether the lecturer indeed taught incorrect information, whether the students misunderstood the information, or whether they erroneously attributed their information acquisition to the lecture situation even though they got it from somewhere else. The critical point could be that they believe they got this incorrect knowledge from their psychology instructor. Such a perceived lecture-based misconception could be particularly difficult to debunk because its holder might view the source of the misconception as an objectively valid source.

4.3 Changing Psychological Misconceptions

Not only are psychological misconceptions widespread, but they are also very hard to change (see, e.g., Bensley et al., 2015; Hughes et al., 2015). Early studies showed that standard teaching approaches (i.e., classical lectures without a focus on misconceptions) have little to no effect on students' endorsement of psychological misconceptions (e.g., Gardner & Dalsing, 1986; McKeachie, 1960; Vaughan, 1977). For instance, the average student from six elementary psychology courses at different institutions still endorsed 85% of the misconceptions they had at the beginning of the course (McKeachie, 1960). In another study, psychology students decreased their endorsements of misconceptions by only about 5% at the end of the course compared with the beginning (Vaughan, 1977). More recent studies have shown small effects of standard teaching regarding the reduction in psychological misconceptions (e.g., Kowalski & Taylor, 2009). Because standard approaches do not seem to achieve a satisfactory reduction in students' psychological misconceptions, more effective approaches are needed. Changing misconceptions is particularly difficult because pre-existing beliefs or knowledge (e.g., misconceptions) need to be reorganized to achieve an integration of the new information, thus, a change in the misconception. This process is known as conceptual change (see Tippett, 2010). Apparently, simply confronting someone with correct information (e.g., standard teaching) is not sufficient to achieve conceptual change (see, e.g., McKeachie, 1960; Vaughan, 1977). Therefore, other versions of confronting have been investigated, and there is a long tradition of research on one specific approach that has the potential to achieve conceptual change and reduce misconceptions from different fields, namely, refutation texts (see, e.g., Aguilar et al., 2019; Braasch et al., 2013; Broughton et al., 2010; Guzzetti et al., 1997; Kendeou et al., 2014, 2016, 2019; Lassonde et al., 2016; Nussbaum et al., 2017; Tippett, 2010; van Loon et al., 2015; Weingartner & Masnick, 2019). Refutation texts activate existing knowledge or beliefs (i.e., a misconception) and, in close proximity, mention that this knowledge or belief represents a misconception. In addition, refutation texts also present new

and correct information regarding the topic and explain why the previously held belief or assumed knowledge is incorrect (see, e.g., Bensley & Lilienfeld, 2017; Guzzetti, 2000; Lassonde et al., 2016, 2017; Sinatra & Broughton, 2011; Tippett, 2010). Thus, refutation texts are said to trigger conceptual change due to the simultaneous activation of the misconception and new, correct information, thereby inducing cognitive conflict (see, e.g., Guzzetti et al., 1993; Hynd, 2001; Kendeou et al., 2013, 2019; Kendeou & van den Broek, 2007; Prinz et al., 2019; van den Broek & Kendeou, 2008). Besides refutation texts, other refutation approaches have also been applied in the classroom, for instance, in teaching lectures (e.g., Kowalski & Taylor, 2009, 2017) or in creating and presenting posters (e.g., LaCaille et al., 2019; Lassonde et al., 2017). Lassonde et al. (2017) asked their psychology students from a semester-long research project to create refutation-style posters to counteract psychological misconceptions. Students who were not part of the project then viewed the posters, and results indicated that these refutation-style posters had a strong effect of reducing misconception endorsement. Kowalski and Taylor (2009, 2011, 2017) integrated refutation teaching (i.e., activating a misconception and refuting it with evidence in text and teaching) in their introductory psychology classes and compared it with standard teaching (i.e., providing evidence in text and teaching without activating a misconception). In different studies, they showed that refutation teaching was more effective than standard teaching at reducing psychological misconceptions (Kowalski & Taylor, 2009, 2011). In a more recent study, Kowalski and Taylor (2017) found a lower endorsement of misconceptions through refutations three semesters later.

Even though refutation approaches are a promising way to reduce psychological misconceptions when targeting each misconception directly, they are also said to work for only one misconception at a time. Each specific refutation activates specific prior beliefs or knowledge and presents new information regarding the specific topic. Therefore, cognitive conflict is activated for the refuted topic only (see Kowalski & Taylor, 2009; Taylor & Kowalski, 2019; Tippett, 2010), and it has been argued that refutations lack an overarching

effect that transfers to other misconceptions that are not specifically targeted (see Taylor & Kowalski, 2019). In addition, refutations face the challenge of possible backfire effects (see Bensley & Lilienfeld, 2017; Cook et al., 2015; Lewandowsky et al., 2012; Trevors et al., 2016). Backfire effects (i.e., making people more likely to believe the incorrect information while trying to refute it) might occur through repeating the misinformation while trying to debunk it (see Lewandowsky et al., 2012). Refutations first mention the misconceptions and then refute them directly by stating that the information is wrong and by providing new, correct information (see Lassonde et al., 2016). By mentioning the misconception first, this misinformation becomes familiar and could consequently be reinforced, possibly leading to a backfire effect (see Lewandowsky et al., 2012). Contradicting this theoretical explanation, one recent study showed no evidence of backfire effects from refutations (Ecker et al., 2020). Nevertheless, there is need to investigate additional methods that have a general effect of reducing several misconceptions and ideally do not backfire (see Taylor & Kowalski, 2014).

5. Open Research Questions for This Dissertation

As outlined above, psychological misconceptions are widespread among the general population and psychology students (e.g., Furnham & Hughes, 2014; Hughes et al., 2015; Taylor & Kowalski, 2004; Vaughan, 1977). Thus, it is reasonable to assume that psychological misconceptions are also prevalent among other groups. It has been argued that teachers' endorsements of psychological misconceptions from the educational context can be a threat for EBT (see Ferrero et al., 2020). However, detailed knowledge regarding the prevalence of educational psychological misconceptions among the specific group of preservice teachers—a group that also comes in contact with scientific psychological information throughout their education—is limited. Regarding (preservice) teachers' misconceptions about learning, it is mainly beliefs in neuromyths that have been investigated so far (e.g., Dündar & Gündüz, 2016; Tardif et al., 2015), but knowledge regarding their misconceptions about more general

educational psychological topics is still scare. In addition, most of these studies have been conducted outside Germany (e.g., Blanchette Sarrasin et al., 2019; Dekker et al., 2012; Dündar & Gündüz, 2016; Hermida et al., 2016; Macdonald et al., 2017; Papadatou-Pastou et al., 2017; Pei et al., 2015; Rato et al., 2013; Tardif et al., 2015), and due to cultural and educational differences, findings from different countries cannot be transferred easily to other countries (see, e.g., Glass et al., 2008; McCutcheon et al., 1993). Therefore, one open research question that I addressed in my dissertation was how prevalent different educational psychological misconceptions are among preservice teachers in Germany.

Besides endorsing misconceptions itself, another challenge for the implementation of EBT is (preservice) teachers' preference for anecdotal instead of scientific information. It has been argued that (preservice) teachers devalue research as helpful for practical problems (Hargreaves, 2000) and consider personal experiences or information from colleagues as most important or more important than data (see, e.g., Allen, 2009; Bråten & Ferguson, 2015; Buehl & Fives, 2009; Gitlin et al., 1999; Schildkamp & Kuiper, 2010; Williams & Coles, 2007). Results from one study also indicated that (preservice) teachers named anecdotal evidence as a source of where their knowledge about how to teach comes from (Buehl & Fives, 2009). Regarding the sources of psychological misconceptions, personal experiences have been named in several studies (e.g., Gaze, 2014; Hughes, Lyddy, & Lambe, 2013; Taylor & Kowalski, 2004). Particularly for preservice teachers, personal experiences can play an important role for the formation of their beliefs about the educational context (see Stuart & Thurlow, 2000), and thus, also their misconceptions. It is still an open question whether this preference for anecdotal evidence is also present regarding preservice teachers' formation of educational psychological misconceptions. Therefore, in my dissertation, I hypothesized that preservice teachers would predominantly name anecdotal evidence as the basis of their educational psychological misconceptions, and I investigated whether a predominant reliance on anecdotal sources would be associated with further aspects that contradict EBT.

To enable EBT, (preservice) teachers should be prevented from endorsing educational psychological misconceptions, and they should be confident regarding what they know and what they do not know (yet). Dunn et al. (2013) argued that enhancing students' metacognition is one important goal of education. Achieving metacognition is not only a general goal of education but is also particularly important regarding the identification of and possible reduction in misconceptions (see Bensley & Lilienfeld, 2015, 2017). Overconfidence in misconceptions could hinder people from realizing the necessity to reflect on their supposed knowledge (see Bensley & Lilienfeld, 2017). Thus, overconfidence in misconceptions needs to be reduced. To make it more likely for teachers to enter their professional lives with as few educational psychological misconceptions as possible and as high confidence in their correct knowledge as possible, it is suitable to begin debunking as early as possible, for instance, at preservice teacher training. Refutations have been shown to be useful for reducing students' misconceptions (e.g., Kowalski & Taylor, 2009; Lassonde et al., 2016; Prinz et al., 2019). However, one critique of refutation approaches is that they are not able to reduce more than one misconception with one attempt (see Taylor & Kowalski, 2019), and it has been argued that refutations may backfire (see Bensley & Lilienfeld, 2017; Cook et al., 2015; Lewandowsky et al., 2012; Trevors et al., 2016). Thus, another open research question that I addressed with this dissertation was whether refutation approaches (i.e., refutation texts and refutation lectures) can successfully reduce preservice teachers' educational psychological misconceptions and whether other approaches may have a general effect on the endorsement of various psychological misconceptions without targeting them directly. Furthermore, it has been shown that standard lectures are able to enhance students' confidence in their knowledge regarding topics that have been targeted in the lecture (Dutke & Barenberg, 2009), and this could also be true for refutation lectures. Hence, I investigated whether these approaches also have an enhancing effect on preservice teachers' metacognitive monitoring accuracy. In addition, the previous literature has mostly concentrated on short-term effects of reducing misconceptions

through refutation approaches (e.g., Kowalski & Taylor, 2011; Lassonde et al., 2016; see also Hughes, Lyddy, & Lambe, 2013). To make it possible for preservice teachers to later in life become teachers who do not endorse educational psychological misconceptions, achieving enduring effects is one important step. Therefore, in this dissertation, I also focused on possible long-term effects.

6. Summaries of the Empirical Studies Included in This Dissertation

In the following, I present the findings of the three empirical studies that were conducted to answer the open research questions outlined above. The three papers are included at the end of this dissertation.

6.1 Prevalence of Educational Psychological Misconceptions Among German Preservice Teachers (Paper 1: Menz et al., 2020)

In Paper 1, we focused on the prevalence of educational psychological misconceptions among preservice teachers and also investigated the effects of refutation texts to reduce these misconceptions. To answer the open research question of how widespread different educational psychological misconceptions are among German preservice teachers, we examined the absolute prevalence rates of misconceptions about four educational psychological topics (i.e., learning styles, multiple intelligences, testing effect, class size). In addition, we also examined the prevalence of misconceptions about four general scientific topics (i.e., climate change, evolution, vaccinations, HIV) to gain insights into the severity of the prevalence rates of educational psychological misconceptions in comparison with general scientific misconceptions. Results indicated a high prevalence of misconceptions regarding learning styles (95.0%), multiple intelligences (88.2%), and class size (85.6%), whereas only 7.9% of the preservice teachers endorsed a misconception about the testing effect. We also found that, in comparison with the endorsement of general scientific misconceptions (mean

prevalence = 10.4%), the endorsement of educational psychological misconceptions was shocking (effect size d = 4.00).

Another focus of this study was to conduct a combined investigation of preservice teachers' preferences for anecdotal evidence and refutation texts for reducing educational psychological misconceptions. We formulated refutation texts for each of the abovementioned four educational psychological topics and presented them as either empirical evidence (i.e., as a refutation text with empirical research findings) or anecdotal evidence (i.e., as a refutation text with personal experiences from a companioned teacher) in a between-subjects design. In line with our expectations, the results showed that preservice teachers' endorsement of educational psychological misconceptions was lower after they read the refutation texts compared with before they read the texts. However, contrary to our expectations, preservice teachers showed a stronger reduction in misconception endorsement after they read the empirical version of the refutation text than after they read the anecdotal version. In addition, for the three topics with high prevalence rates of misconceptions, only a minority of our sample rigorously changed their misconceptions (i.e., from agreeing with a false statement before reading the text to not agreeing with the false statement after reading the text), with more participants changing their misconceptions rigorously after reading the empirical version (about 20%) compared with the anecdotal version (about 5%) of the refutation text. On the one hand, the results of this study show that preservice teachers in Germany were indeed found to endorse educational psychological misconceptions, which constitutes a threat to EBT. On the other hand, the finding that preservice teachers were more likely to change their misconceptions after reading the empirical compared with the anecdotal refutation texts indicates a trust in empirical information, which is promising for achieving EBT.

6.2 Sources of Preservice Teachers' Educational Psychological Misconceptions (Paper 2: Menz et al., 2021)

In Paper 2, we focused on the sources of preservice teachers' educational psychological misconceptions and examined whether relying more on anecdotal sources compared with scientific sources is associated with attributes that stand in contrast to EBT (i.e., having more misconceptions, changing misconceptions less after reading an empirical refutation text, and judging specific educational psychological topics as not scientifically examinable). Results showed that preservice teachers indeed named more anecdotal sources (i.e., personal experience and narratives from other people) compared with scientific sources (i.e., lectures and scientific research) when asked about what they based their beliefs about 14 different educational psychological topics on, and this was also true for their misconceptions in particular. However, scientific sources—mainly lectures—were also named quite often as a source of preservice teachers' general beliefs and misconceptions.

To investigate whether sourcing more from anecdotal information than from scientific information was associated with different attributes that stand in contrast to EBT (see above), we divided the sample into two groups on the basis of how important they considered either anecdotal or scientific information to be with respect to the formation of their studied beliefs. Results showed that primarily anecdotal-sourcing preservice teachers (who based their beliefs more on anecdotal than scientific sources) indeed endorsed more educational psychological misconceptions and also showed a weaker reduction in their misconceptions about learning styles after reading the empirical refutation text we developed for Paper 1 when compared with primarily scientific-sourcing preservice teachers (who based their beliefs more on scientific than anecdotal sources). Contrary to our expectations, the two groups did not differ in their judgment of whether educational psychological topics are scientifically examinable. Even though we could not draw causal conclusions due to the design of our study, the result that

undesirable aspects (i.e., having more misconceptions, changing misconceptions less after reading an empirical refutation text) were associated with basing one's beliefs more on anecdotal information corroborates the idea that anecdotal evidence should not be the primary source of (preservice) teachers' beliefs and knowledge acquisition about topics that are relevant for their (future) work life because this can hinder EBT.

6.3 Reducing Educational Psychological Misconceptions and Enhancing Metacognitive Monitoring Accuracy (Persistently) Among Preservice Teachers (Paper 3: Menz et al., in press)

In Paper 3, we focused on various approaches to achieve a—possibly enduring—reduction in educational psychological misconceptions and enhancement of metacognitive monitoring accuracy among preservice teachers. To answer the open research questions of whether refutation lectures are an appropriate method for achieving enduring effects of reduction and whether other approaches are effective at reducing misconceptions in general, we investigated three different approaches: a standard lecture, a refutation lecture, and a group that received instruction in information evaluation strategies. In addition, we wanted to understand how to support preservice teachers in knowing what they know and what they do not know because such metacognition can have an influence on misconceptions (see Bensley & Lilienfeld, 2017). Therefore, we investigated the effects of the three approaches on metacognitive monitoring accuracy. In this study, we had three measurement occasions (i.e., beginning of the semester, end of the semester, follow-up half a year later), and we included three different samples: preservice teachers taking a one-semester standard educational psychology lecture (i.e., standard group), preservice teachers taking a one-semester educational psychology lecture that included refutations for diverse educational psychological misconceptions (i.e., refutation group), and preservice teachers from different universities who did not take a specific lecture during the investigated semester but received an online intervention on how to evaluate information analytically combined with information about

cognitive biases (i.e., information evaluation group). Results on reductions in misconception endorsement showed large effects for the refutation group: For both the refuted topics and the nontargeted topics, misconception endorsement was significantly reduced over time, and for the refuted topics, the effect even occurred at the follow-up investigation. Results for the standard group showed smaller effects of reduction on the targeted topics only, and they were not persistent. In the information evaluation group, there were no effects of reduced misconception endorsement (neither short- nor long-term). Results regarding the enhancement of metacognitive monitoring accuracy were identical: Refutations had large effects of enhancing metacognitive monitoring accuracy for refuted and nontargeted topics (with enduring effects for refuted topics), the standard lecture had small effects of enhancing metacognitive monitoring accuracy for targeted topics only, but they were not enduring, and instruction in information evaluation strategies did not have any effects of enhancing metacognitive monitoring accuracy. Taken together, the results of Paper 3 showed that particularly refutation lectures are a promising way to achieve both an enduring small number of misconceptions and a long-term high metacognitive monitoring accuracy regarding educational psychological topics among preservice teachers. Regarding EBT, these results are explicitly encouraging: First, they show that an evidence-based approach (i.e., using refutations) is effective in real-life settings with preservice teachers. Second, this approach enables long-term results on misconception reduction and metacognitive monitoring enhancement, thus leading to an optimal basis for preservice teachers to adopt EBT later in life.

7. General Discussion

Due to a rising post-truth era (see Laybats & Tredinnick, 2016; Lewandowsky et al., 2017; Sismondo, 2017) and the central role of (preservice) teachers as distributors of knowledge and role models (see Commission of the European Communities, 2007), the aim of this dissertation was to investigate German preservice teachers' educational psychological

misconceptions as one factor that could hinder EBT. By taking into consideration recent findings on psychological misconceptions among different populations (e.g., Bensley & Lilienfeld, 2015; Bensley et al., 2014, 2015; Furnham, 2018; Furnham & Hughes, 2014; Kowalski & Taylor, 2004, 2009, 2017; Kuhle et al., 2009; LaCaille et al., 2019; Lyddy & Hughes, 2012; McCarthy & Frantz, 2016; Sibicky et al., 2020; Taylor & Kowalski, 2004, 2012), (preservice) teachers' preference for anecdotal information (e.g., Bråten & Ferguson, 2015; Costa et al., 2000; Williams & Coles, 2007), and promising results on the use of refutation approaches to counteract misconceptions (e.g., Aguilar et al., 2019; Braasch et al., 2013; Kendeou et al., 2014, 2016, 2019; Kowalski & Taylor, 2009, 2017; Lassonde et al., 2016; Nussbaum et al., 2017; Tippett, 2010; van Loon et al., 2015), the present work combined these threads by targeting the prevalence and origins of as well as reductions in preservice teachers' misconceptions on the one hand and negative aspects that are associated with relying more on anecdotal than on scientific evidence on the other hand. In the following sections, the results from Papers 1, 2, and 3 of this dissertation are integrated into previous literature and discussed together while also addressing their strengths and limitations, avenues for future research, and practical implications in the context of teacher training. I end this dissertation with a general conclusion.

7.1 Prevalence of Different Educational Psychological Misconceptions

Previous research regarding (preservice) teachers' misconceptions has focused primarily on subject-related misconceptions (e.g., Bayraktar, 2009; Butler et al., 2015; Kaltakci-Gurel et al., 2016; Ryan & McCrae, 2006; Stein et al., 2008; Yates & Marek, 2014) or beliefs in neuromyths (e.g., Blanchette Sarrasin et al., 2019; Dekker et al., 2012; Dündar & Gündüz, 2016; Ferrero et al., 2016; Gleichgerrcht et al., 2015; Grospietsch & Mayer, 2018; Hermida et al., 2016; Krammer et al., 2019; Lethaby & Harries, 2016; Pei et al., 2015; Rato et al., 2013; Tardif et al., 2015). With this dissertation, I was able to investigate the prevalence of

another important group of misconceptions: educational psychological misconceptions. Paper 1 covered the prevalence of four educational psychological misconceptions, Paper 2 additionally covered the prevalence of another 14 educational psychological misconceptions, and Paper 3 covered the prevalence of an additional five educational psychological misconceptions while also including 13 misconceptions we or other researchers (Pieschl et al., 2019) recently covered in comparable populations. Thus, this dissertation broadens the current state of knowledge about preservice teachers' misconceptions by adding information about the prevalence of 23 different educational psychological misconceptions, with nearly half of the topics considered in two different studies. Even though these misconceptions were analyzed in different samples and using different methods, it is still worthwhile to consider the prevalence in general: A large diversification of prevalence emerged, with prevalence rates ranging from 7.9% to 95.0%. Regarding the extensively investigated neuromyth about learning styles, this dissertation covered both the misconception about the existence of effective learning styles (Paper 1) and the misconception about the effectiveness of adapting teaching to students' learning styles (Paper 3). For these slightly different items, we found prevalence rates of 95.0% in Paper 1 and 86.1% in Paper 3. These prevalence rates of two items that cover different aspects of the learning styles misconception are comparable to each other, which could be interpreted to mean that preservice teachers might not really have a profound grasp of what learning styles might be (good for) but rather generally believe in the idea that they must exist, and (therefore), that matching one's teaching to them must be effective. Moreover, these prevalence rates are also comparable to previously reported prevalence rates in different countries: Newton and Salvi (2020) recently conducted a pragmatic systematic review of 37 studies and found that, on average, 89.1% of (preservice) teachers from these studies believed in the neuromyth about matching instruction to learning styles.

Investigating the prevalence of preservice teachers' misconceptions about different educational psychological topics is an area of research that has been attracting increasing

attention in recent years (e.g., Asberger et al., 2020; Eitel et al., 2019; Pieschl et al., 2019). What all of these studies as well as the papers included in this dissertation have in common is that they have found a wide range of misconception prevalence rates in one investigation, which indicates a topic-specific distribution of misconceptions. For example, Asberger et al. (2020) developed a German questionnaire that measures misconceptions about educational topics. This Questionable Beliefs in Education-Inventory (QUEBEC) covers four topics: direct instruction, effects of class size, feminization of elementary education, and grade retention. Whereas the endorsements of misconceptions about the effects of class size and direct instruction were quite high (means of 4.71 and 4.23, respectively, on a 6-point scale), the endorsement of the misconception about feminization was rather low (mean of 1.99 on the same scale). Also, Pieschl et al. (2019) found that not all of the misconceptions they investigated regarding educational psychology were equally widespread among a preservice teacher sample from Australia: For some topics (e.g., dyslexia, effects of teachers' expectations on students' performance), prevalence rates were below 30%, whereas for other topics (e.g., learning styles, seductive details), they exceeded 90%. From these and our own studies, which all considered preservice teachers' misconceptions about topics from the educational context, it can be reasoned that the endorsement of misconceptions is topic-specific. These findings are also in accordance with previous research investigating students' psychological misconceptions (e.g., Bensley & Lilienfeld, 2015; Furnham & Hughes, 2014; Gardner & Brown, 2013). The topic specificity of misconception endorsement supports the idea that misconceptions are independent of each other and need to be targeted separately (see Taylor & Kowalski, 2019), and it implies that the existence of each possible misconception needs to be examined for every target person due to the fact that, just because one misconception exists, it cannot be concluded that other misconceptions exist, too.

In Papers 1 and 2, a misconception was defined as rather or very much agreeing with a statement that is not in accordance with the current state of research or rather not or not at all

agreeing with a statement that is in accordance with the current state of research (see, e.g., Gardner & Brown, 2013; Hughes et al., 2015). In Paper 3, a different method was used to measure misconceptions: A misconception was defined as judging a statement that is not in accordance with the current state of research as true and indicating a certainty in this judgment that is above 4 on a 10-point scale or judging a statement that is in accordance with the current state of research as false and indicating a certainty in this judgment that is above 4 on a 10-point scale (see Taylor & Kowalski, 2004). With these different measurements, it is interesting to compare the prevalence rates of misconceptions that were investigated in either Papers 1 and 2 or Paper 3 because it has been argued that misconception measurement can have an influence on prevalence rates (see, e.g., Bensley & Lilienfeld, 2015; Taylor & Kowalski, 2012). For example, regarding the misconception about the existence of multiple intelligences, we found a prevalence of 88.2% in Paper 1 and a nearly identical prevalence of 87.2% in Paper 3. Also regarding the misconception that mathematical and verbal abilities are exclusive, comparable prevalence rates of 71.9% in Paper 2 and 70.3% in Paper 3 were found. A slightly different but still comparable pattern was found for the misconception that humans use only 10% of their brain: 43.3% endorsed this misconception in Paper 2, whereas only 36.1% did so in Paper 3. Taken together, these descriptive comparisons do not give the impression that measurement had a strong influence on the prevalence rates. Rather, they indicate that the prevalence rates have high validity because we investigated different but comparable samples and still found comparable prevalence rates for most of the topics.

Another aspect of misconception measurement that needs to be discussed involves the use of either true/false formats or conflicting statements. It has been argued that a true/false measurement of misconceptions artificially inflates prevalence rates (see, e.g., Taylor & Kowalski, 2012). Some authors have therefore suggested that two conflicting statements should be contrasted against each other and that a decision should be forced for one of them instead (see, e.g., Bensley et al., 2014), whereas other authors have suggested that researchers should

stick with the use of one item but use Likert-type scales with an additional answer category of "I do not know" instead of solely true/false formats (e.g., Gardner & Brown, 2013). Pieschl et al. (2019) used the contrasting measurement to investigate the prevalence of educational psychological misconceptions among preservice teachers from Australia. In Paper 3, we also investigated three items from Pieschl et al.'s study (2019) with the measurement described above (i.e., true/false rating plus certainty on a 10-point scale). Interestingly, we found lower prevalence rates in Paper 3 versus the study by Pieschl et al. (2019) for the misconceptions about bullying (60.9% vs. 90.8%), seductive details (69.5% vs. 93.3%), and brainstorming (74.4% vs. 97.5%). Either these differences could have occurred due to country-specific differences (see, e.g., Glass et al., 2008; McCutcheon et al., 1993) or they could be interpreted as a hint against the claim that true/false measurements automatically inflate the prevalence rates of misconceptions.

In sum, the research findings implemented in this dissertation indicate a topic specificity of misconception endorsement as well as a negligible influence of misconception measurement on the measured prevalence. Moreover, our research findings as well as other recently published work (e.g., Asberger et al., 2020; Eitel et al., 2019) indicate a high prevalence of different educational psychological misconceptions among German preservice teachers. Even though these studies also found low prevalence rates for some topics, the prevalence rates for other topics (e.g., class size, learning styles) are still alarmingly high. Therefore, investigating preservice teachers' educational psychological misconceptions has justifiably become a rising area of research and should receive further attention to support preservice teachers in becoming teachers who act in accordance with the current state of research regarding topics from their field of expertise.

7.2 Preservice Teachers' Preference for Anecdotal Information

(Preservice) teachers' preference for anecdotal information over scientific or empirical information (e.g., Allen, 2009; Bråten & Ferguson, 2015; Clark, 1988; Costa et al., 2000; Gitlin et al., 1999; Hargreaves, 2000; Schildkamp & Kuiper, 2010; Williams & Coles, 2007) stands in contrast to EBT. In Papers 1 and 2, we directly took a closer look at this previously postulated preference for anecdotal information among preservice teachers, and in Paper 3, it was possible to indirectly take a look at preservice teachers' acceptance of scientific findings: We investigated whether preservice teachers changed their misconceptions after receiving scientific refutation information during a lecture program. The combination of our research findings neither fully supported nor entirely contradicted a preference for anecdotal information among preservice teachers.

On the one hand, we found empirical evidence that preservice teachers prefer anecdotal information over scientific information and that this preference is associated with further undesirable aspects that stand in contrast to EBT: Even though a large proportion of preservice teachers was also classified as primarily scientific-sourcing (see below), the majority of our sample was classified as primarily anecdotal-sourcing (nearly 60%), which means that more than half of our preservice teacher sample named more anecdotal sources than scientific sources for their beliefs about different educational psychological topics. In addition, we found that these primarily anecdotal-sourcing preservice teachers endorsed more misconceptions and that they changed their misconceptions about the effectiveness of learning styles less after reading a refutation text that presented empirical information when compared with primarily scientific-sourcing preservice teachers. This finding can be interpreted as a hint that a preference for anecdotal information contradicts EBT because this preference is associated with the endorsement of more misconceptions (i.e., assumptions that contradict scientific research, see Taylor & Kowalski, 2014) and less change in one's misconceptions after being given

empirical information. Moreover, the finding that preservice teachers predominantly relied on anecdotal information to form their beliefs about educational psychological topics stands in contrast to common standards for teacher education that ask teachers to base their teaching and learning on research findings (see, e.g., Commission of the European Communities, 2007; KMK, 2004), thus, also standing in contrast to EBT.

On the other hand, we found evidence that preservice teachers rely on scientific information and consider it when forming or changing their knowledge or beliefs about educational psychological topics: First, preservice teachers attributed a large proportion of their beliefs about different educational psychological topics to scientific evidence. In addition, almost 40% of our preservice teacher sample from Paper 2 attributed their beliefs to a stronger extent to scientific sources than to anecdotal sources and were therefore classified as primarily scientific-sourcing. Second, in Paper 1, reading an empirical refutation text led to a stronger reduction in misconception endorsement than reading an anecdotal refutation text, and more preservice teachers rigorously changed their misconceptions after reading the empirical version compared with the anecdotal version. Third, in Paper 3, we found that scientific refutation information for nine educational psychological misconceptions imbedded in a one-semester lecture program had a strong effect of reducing the endorsement of misconceptions. This effect can be interpreted as contradicting the assumption that preservice teachers oppose research information. Taking these findings from the three presented empirical studies into consideration, it cannot be argued that preservice teachers devalue scientific information from the educational context or rely on anecdotal information only (cf. Hargreaves, 2000; Sjølie, 2014).

In sum, the results from the three empirical studies included in this dissertation add to the literature by unraveling the negative assumption about preservice teachers' preference for anecdotal information. In Paper 2, which focused primarily on this assumption, a preference for

anecdotal over scientific information as well as associated undesirable outcomes that contradict EBT were found. These findings are in accordance with previous literature that has indicated that (preservice) teachers attribute their knowledge acquisition to anecdotal sources (see, e.g., Buehl & Fives, 2009). However, the results likewise indicate that preservice teachers also turn to scientific information when they build or change their beliefs about educational psychological topics. These findings are in accordance with recent literature that has indicated that preservice teachers ascribe high practical value to scientific sources (see, e.g., Merk et al., 2017; Thomm et al., 2021). Hence, on the basis of the findings from my dissertation, I argue that preservice teachers' attitudes toward research findings are not as negative as previously proclaimed (e.g., Hargreaves, 2000) and thus need further investigation. In detail, exploring how scientific information needs to be presented to be as compelling as possible could be a valuable approach. Also, finding out more about the specific situations (e.g., discussions with colleagues or developing new teaching concepts) in which certain kinds of information (e.g., anecdotal or scientific) might be attractive for certain subgroups of educational experts (e.g., preservice teachers for primary or secondary education) could help to draw a clearer picture.

7.3 Refutations: Reducing Educational Psychological Misconceptions and Enhancing Metacognitive Monitoring Accuracy

Besides shedding light on the prevalence and origins of educational psychological misconceptions, approaches to reduce these misconceptions are very important for fostering EBT. In Papers 1 and 3, we focused on investigating a promising approach that could be applied to reduce educational psychological misconceptions among preservice teachers: refutations. Different studies in different disciplines have used refutation texts to counteract students' misconceptions (e.g., Aguilar et al., 2019; Braasch et al., 2013; Danielson et al., 2016; Kendeou et al., 2014, 2019; Lassonde et al., 2016; Nussbaum et al., 2017; van Loon et al., 2015;

Weingartner & Masnick, 2019; see also Tippett, 2010). This approach was followed in Paper 1 by developing short refutation texts on four educational psychological topics. Especially the empirical refutation text led to a strong reduction in misconception endorsement for all topics, and 15% to 70% of the sample even rigorously changed their misconceptions. Though it was not the focus of Paper 2, it offered the opportunity to replicate the finding on the efficacy of the refutation text about learning styles, indicating a similar pattern: The refutation text was again powerful in reducing preservice teachers' misconception about the effectiveness of learning styles, and about 15% of the sample rigorously changed their misconception. The combination of these findings indicates that, in line with previous research (e.g., Broughton et al., 2010; Lassonde et al., 2016), the developed refutation texts were appropriate for counteracting educational psychological misconceptions in preservice teachers. However, these findings also indicate that short refutation texts did not fully achieve the anticipated effect, namely, a definite rejection of misconceptions in all preservice teachers. It has been argued that some misconceptions might be more difficult to change (see Lassonde et al., 2016). For instance, being confronted with incorrect information that constitutes a misconception at different occasions (e.g., media, school) could reinforce such misconceptions and make them more difficult to change. This could be one explanation for why the anticipated effect was not achieved for everyone and every misconception. However, it still remains unclear for whom refutations work and for whom they do not. For example, besides a preference for anecdotal information (see Paper 2), another reason for a low effectiveness of empirical refutation texts could lie in an insufficient understanding of empirical information. For instance, if someone does not understand the empirical findings presented in a refutation text, they might be less likely to accept the conclusions drawn from these studies, thus not changing their misconception after reading the refutation text.

Building on the promising results of refutation approaches from Papers 1 and 2, my aim was to implement these approaches into a real-life setting in teacher education (see Kowalski

& Taylor, 2009, 2017). An additional aim was to address the open research question of how to find an approach that reduces misconception endorsement without directly refuting specific misconceptions (see Taylor & Kowalski, 2019). Hence, an online intervention that educates preservice teachers about cognitive biases and imparts information evaluation strategies was developed. The results regarding the implementation of refutations in a lecture in teacher education were promising: The refutation approach led to a strong reduction in educational psychological misconceptions that had been refuted during the lecture. In addition, the endorsement of misconceptions that had been refuted in the lecture was still lower half a year later compared with the beginning. These findings are in accordance with previous investigations that showed effective misconception reductions through refutation lectures (e.g., Kowalski & Taylor, 2009, 2011) and even long-term effects in one recent study (Kowalski & Taylor, 2017). Encouragingly, we also found contradictory evidence regarding the specificity of refutations: Even the nontargeted educational psychological misconceptions were reduced over the duration of one semester. Although this finding differed from previously postulated assumptions (see Taylor & Kowalski, 2019), it is very promising regarding practical implications: Maybe including several refutations for different educational psychological misconceptions in a weekly lecture program makes people more suspicious about their previously held beliefs or indeed activates an overarching conceptual framework (see Taylor & Kowalski, 2019) and thus may help to reduce misconceptions in general. Furthermore, with the strong (and enduring) reduction in misconception endorsement through refutations, no evidence that refutations backfired emerged, which is in line with another recently published study (Ecker et al., 2020). As promising as these results are, the new intervention we developed to counteract several misconceptions in one attempt did not prove effective. There were no effects on misconception endorsement from imparting information evaluation strategies. One explanation for the nonappearance of reductions might be an overkill backfire effect (see Lewandowsky et al., 2012). Even though it has been shown that this backfire effect occurs when people are asked

to produce many alternative outcomes for specific situations (Sanna et al., 2002)—which we did not do—it could be argued that asking people to produce many examples of various cognitive biases regarding one topic—which we did do—might have a similar effect, thus making a reduction in misconceptions difficult to achieve through backfiring. Therefore, it remains a task for further research to develop interventions that counteract several misconceptions without directly targeting all of them if our spill-over effects for refutations cannot be replicated in other studies.

Besides enlarging one's knowledge and endorsing as few misconceptions as possible, another important skill students should acquire through education is knowing what they know and what they do not know, that is, metacognition (see Dunn et al., 2013). Such metacognitive processes are essential for learning successfully (see Händel et al., 2020) and could support students in identifying their misconceptions (see, e.g., Bensley & Lilienfeld, 2015). Recently, Prinz et al. (2019) argued that refutation texts can be beneficial for supporting the development of readers' metacomprehension accuracy (i.e., self-assessment of comprehension regarding a text), and Vosniadou et al. (2020) reasoned that metacognitive awareness can be enhanced by a moderate use of dissonance (e.g., inducing cognitive conflict). In Paper 3, we tried to achieve the goal of enhancing metacognitive monitoring accuracy (see Barenberg & Dutke, 2013) through different approaches, including the implementation of repeated refutations in a lecture. We found empirical evidence that refutations have an enhancing effect on metacognitive monitoring accuracy: Regarding all investigated misconceptions (i.e., refuted and nontargeted), metacognitive monitoring accuracy improved significantly over the duration of the lecture. In addition, for the refuted misconceptions, there was no evidence that our measure of metacognitive monitoring accuracy differed significantly from 0, which indicates a perfect match between performance and confidence. These findings support Dunn et al.'s (2013) claim that metacognition can be enhanced by using EBT (e.g., by using refutations in lectures) as well as the assumption by Prinz et al. (2019) that refutations are effective for achieving

metacomprehension. The finding of an overarching effect on topics that have not been targeted in the lecture can be interpreted to mean that students learned what they know and what they do not know, irrespective of whether they learned new content regarding specific topics. Perhaps the repeated refutations made them realize that they had flawed mental models for some topics, leading to the assumption that this could also be true for other, nontargeted topics. This improvement in metacognitive monitoring accuracy is promising because high metacognitive skills can support these students throughout their future studies and could also make them less prone to endorsing misconceptions. In addition, becoming less overconfident regarding one's knowledge—as shown in Paper 3—helps to identify and target knowledge gaps (see, e.g., Roelle et al., 2017).

Taken together, the combination of our results from the three empirical studies adds to the literature by applying refutation approaches to preservice teachers and their educational psychological misconceptions as well as their metacognitive monitoring accuracy. This dissertation addressed both popular formats of refutations, that is, refutation texts (e.g., Kendeou et al., 2014, 2019; Lassonde et al., 2016) and refutation lectures (e.g., Kowalski & Taylor, 2009, 2017) and found promising results for both. Moreover, especially the results from the longitudinal study with three measurement points extend previous findings by showing that long-term effects of reducing misconception endorsement can be achieved through refutations implemented in lectures at university (see Kowalski & Taylor, 2017). This dissertation also contributes to the literature by showing that refutations enhance metacognitive monitoring accuracy, which should support preservice teachers' future learning (see Händel et al., 2020) and might support them in realizing when their beliefs or knowledge need to be revised (see Bensley & Lilienfeld, 2017).

7.4 Strengths and Limitations

By addressing preservice teachers' misconceptions about educational psychological topics, this dissertation covered a rising research area: Whereas previously, the focus regarding (preservice) teachers' misconceptions lay on neuromyths (e.g., Blanchette Sarrasin et al., 2019; Dekker et al., 2012; Grospietsch & Mayer, 2018), more recently, research has begun to target a variety of educational psychological misconceptions among preservice teachers (e.g., Asberger et al., 2020; Eitel et al., 2019; Pieschl et al., 2019). The present dissertation has strongly contributed to this emerging field of research with three empirical research studies that directly built upon each other. In addition, the number of participants and the number of misconceptions that were investigated in this dissertation were substantial: In total, misconceptions among N = 2,038 preservice teachers and the prevalence of 23 different misconceptions (with 11 of them covered twice) were included in this dissertation. By covering the same misconceptions in different studies, I was able to compare prevalence rates in different samples, which allowed me to evaluate whether these prevalence rates were sample-specific or represented actual misconceptions. The results of the three studies included in this dissertation point to the interpretation that the investigated misconceptions rather represent actual misconceptions than sample specificities because most of the prevalence rates were comparable across studies. Regarding the choice of topics for possible misconceptions, different sources were used: Some topics have been covered in previous studies (e.g., Dekker et al., 2012; Pieschl et al., 2019), others have been labeled educational myths, but their endorsement has not necessarily been examined empirically (see de Bruyckere et al., 2015), and further topics were chosen because they revealed a high level of misunderstanding in lectures for preservice teachers at Heidelberg University. While choosing the topics, I paid particularly close attention to their relevance: All of the investigated topics have in common that they are important for preservice teachers' future professional lives, and therefore, constitute topics about which preservice teachers should not endorse misconceptions when they leave university.

One particular strength of this dissertation is that I implemented one part of it into a real-life setting in combination with a longitudinal quasi-experimental design. The study reported in Paper 3 was conducted in cooperation with Dr. Anne Weidinger from the TU Dortmund University who taught a standard educational psychology lecture for preservice teachers. At Heidelberg University, Dr. Eva Seifried implemented a refutation educational psychology lecture for preservice teachers. Accordingly, this design allowed us to compare the effects of two different lectures on reducing misconception endorsement and enhancing metacognitive monitoring accuracy. Both dependent variables were assessed not only at the beginning and the end of the academic summer term 2019 but also again half a year later. Thus, with this dissertation, not only was I able to initially investigate refutation approaches for preservice teachers' misconceptions with an experimental design (Paper 1), but I was also able to transfer the gained and adapted knowledge into an elaborated research design with a follow-up investigation (Paper 3).

The type of misconception measurement that I used in my dissertation comprises both strengths and limitations. It has been argued that the wording used in misconception measurements plays a particularly important role (see Hughes, Lyddy, & Kaplan, 2013), and I argue that formulating perfectly clear items that can be used as contrasting statements to misconceptions (see, e.g., Bensley & Lilienfeld, 2015; Bensley et al., 2014, 2015; Pieschl et al., 2019) enhances this influence of wording. Therefore, I decided to adopt another type of measurement that has been used extensively in previous research (see, e.g., Furnham & Hughes, 2014; Gardner & Brown, 2013; Gardner & Dalsing, 1986; Taylor & Kowalski, 2004): In all studies included in this dissertation, we used one statement and asked preservice teachers for their evaluation of this statement. Moreover, we measured the strength of the misconceptions, either in the form of Likert-type scales or in addition to a true/false format, and each type of measurement included a "neither/nor" or "I do not know" category to counteract response biases and to ensure that participants were not forced to take a stand. Thus, whereas our

measurement of misconceptions can be interpreted as a strength because different types have been put to the test, it can also be interpreted as a limitation because, with these approaches, we could not "distinguish tacit acceptance from the failure to consider the alternative" (Bensley & Lilienfeld, 2015, p. 285).

Besides the several strengths that this dissertation has, there are also limitations that must be taken into consideration when interpreting the results. One limitation refers to the measure of self-reported data and the absence of behavioral information. In all studies included in this dissertation, preservice teachers reported their endorsement of educational psychological misconceptions as well as, in Paper 2, the origins of their beliefs about educational psychological topics. Even though self-reports can be criticized, misconceptions can be described as a person's strong and "deeply ingrained" beliefs (Hughes, Lyddy, & Lambe, 2013, p. 21), and therefore, assessing these beliefs via self-report measures appears to be appropriate. Nevertheless, one interesting application of research we did not cover was investigating whether holding misconceptions is associated with related behavioral outcomes. On the one hand, a recent study showed that 64% of higher education teachers agreed to accommodate different learning styles in their teaching (Newton & Miah, 2017), and another study showed that more than 95% of teachers who believed in the effectiveness of learning styles reported using learning styles with their students (Blanchette Sarrasin et al., 2019). On the other hand, one study showed that award-winning teachers endorsed the same number of neuromyths compared with preservice teachers or non-award winning teachers, which was interpreted as an argument that holding incorrect beliefs about neuroscientific topics does not necessarily lead to poor teaching (Horvath et al., 2018). To shed more light on the actual transferability of misconceptions to detrimental behavior, it would be very interesting to see whether comparable incorrect beliefs for other topics are displayed in classroom behavior. For example, finding out whether an incorrect belief in the exclusivity of verbal and mathematical abilities leads teachers to suggest that their verbally talented students should not pursue a career that requires

mathematical competencies or vice versa could be an indicator of the severity and impact of (preservice) teachers' misconceptions.

Another limitation of this dissertation concerns the disregard of topic specificity and individual differences. Especially in Papers 2 and 3, we combined all misconceptions of each participant to investigate where they came from and whether they changed. With this type of analysis, we did not account for possible topic specificity or individual differences. It could be the case that, for example, the effect of refutations differs with regard to various topics or specific personal attributes; perhaps refuting misconceptions with scientific information works better for scientifically based misconceptions and for people who are well-educated regarding how scientific methods work. Further, it is possible that beliefs about particular topics are especially likely to be based on anecdotal information, whereas others typically derive from scientific information. For instance, the misconception that humans use only 10% of their brain is rather unlikely to be based on personal experience, whereas the misconception that highly gifted children typically encounter many social problems quite likely derives from anecdotal information. Moreover, like previous research (e.g., Taylor & Kowalski, 2004), we did not investigate the real sources of preservice teachers' misconceptions but rather what sources preservice teachers recalled to base their knowledge acquisition on. However, as outlined above, I argue that the perceived sources are at least as important as the real sources because, for example, attributing one's knowledge acquisition to a university lecture might make this misconception particularly likely to stick due to the perception that it came from a trustworthy source.

7.5 Future Research and Practical Implications

This dissertation contributes to the emerging field of research about preservice teachers' educational psychological misconceptions. Of course, there are still many open research questions that need to be addressed in future research. First, different authors have considered

different educational psychological misconceptions (e.g., Asberger et al., 2020; Eitel et al., 2019; Pieschl et al., 2019), but it remains an open task for research to combine these findings. In some studies, some of the investigated topics were the same, but the wording was slightly different or different aspects of the topic were covered, for example, regarding "dyslexia" by Pieschl et al. (2019) and in Paper 3 of this dissertation. Future research should bring these initial insights acquired by different studies together and develop a methodologically sound instrument that measures different educational psychological misconceptions among preservice teachers. The abovementioned QUEBEC (Asberger et al., 2020) could be a starting point; however, it covers only four topics so far. To further develop such an inventory, different types of misconception measurement should be compared with each other so that the most reliable and predictive measurement can be implemented. In addition, further topics that have not yet been investigated should be included in this inventory. A sound inventory that is used by different authors in various studies offers the opportunity to directly compare prevalence rates and reducing approaches, thus leading to a deeper understanding of educational psychological misconceptions among preservice teachers.

Second, one open research question refers to the influence of misconceptions on actual behavior. The endorsement of educational psychological misconceptions among preservice teachers stands in contrast to EBT because misconceptions constitute beliefs that are contradicted by scientific research (see, e.g., Taylor & Kowalski, 2014). Understandably, it has been argued that building educational practice on myths can cause harm directly or indirectly (see Ferrero et al., 2020; Pasquinelli, 2012). However, whether the endorsement of particular misconceptions indeed transfers to actions in accordance with these misconceptions, and thus, not in accordance with scientific research findings, has not been investigated in detail. Regarding learning styles, there is initial evidence that teachers' misconceptions can be transferred to their teaching practice (see, e.g., Blanchette Sarrasin et al., 2019). Nevertheless, it still needs to be investigated whether this transfer of incorrect beliefs into practice can be

found for more general educational psychological misconceptions and whether it has negative consequences on those teachers' students. Educational psychological misconceptions can have various impairing influences, with some of them being more closely linked to a direct impairment of EBT than others. Whereas believing in learning styles obviously impacts teachers' behavior in the classroom, other misconceptions rather lie outside teachers' sphere of influence. For example, endorsing the misconception about class size (i.e., erroneously believing that the number of students in one class influences the learning outcome of this class) is rather difficult to transfer into actual classroom behavior. Hence, this misconception might tend to influence attitudes toward educational policies instead of actual behavior in the classroom. However, a negative attitude itself could impair EBT when it transfers to other topics or hinders further involvement with the topic in question. Therefore, future research is needed to disentangle the specific ways in which different misconceptions are threatening for EBT. Besides asking preservice teachers whether they would adapt their teaching to different learning styles or other incorrect beliefs, it might be worthwhile to investigate educational psychological misconceptions among preservice teachers who are in the practical phase of their teacher education. By doing so, a combination of their misconceptions as well as their educational practice could be analyzed together as a first insight. Then, in a second step, teachers' misconceptions and their classroom behavior could also be the focus of further investigations that concentrate on practicing teachers who are not pursuing their education anymore.

Third, it remains an open question why refutations work for some students and some misconceptions, whereas they do not work or work less for other students and other misconceptions (see Taylor & Kowalski, 2019). For example, in Paper 1, we found that reading empirical refutation texts made only about 20% of our sample change their misconception rigorously. To follow this up in Paper 2, we investigated whether preservice teachers who name predominantly anecdotal sources as the origins of their beliefs about specific educational psychological topics would be less likely to show change in their misconception after reading

the same text compared with primarily scientific-sourcing preservice teachers. Indeed, we found that only 10.1% of the primarily anecdotal-sourcing preservice teachers could be convinced to change their misconception from reading an empirical refutation text, whereas 18.3% of the primarily scientific-sourcing preservice teachers did so. This finding can be interpreted as a first hint that individual differences and attributes matter for the effectiveness of refutations. However, also because only a minority of both groups rigorously changed their misconception, this still needs to be investigated further. For example, future research could explore whether the (perceived) origins of misconceptions play a role in how to refute them or whether a threatened worldview constitutes an obstacle to refutations (see Lewandowsky et al., 2012).

Another open research question involves the development of attempts to reduce several misconceptions together without directly targeting them one at a time. An intervention that was designed to do this was implemented in Paper 3 but did not prove effective. It could be investigated whether extending this intervention by adding feedback or allowing for more time to practice leads to misconception reduction and enhancement of metacognitive monitoring accuracy. Evaluation strategies could be considered a skill and might thereby need time and practice to develop as one recent study showed that practice and feedback have beneficial effects on metacognitive judgments and their accuracy (see Händel et al., 2020). Even though educating preservice teachers about cognitive biases—as done in Paper 3—could constitute one part of an approach that attempts to reduce misconceptions without directly targeting them, other aspects need to be addressed, too. For example, a general training on critical thinking could be promising because it has been shown that critical thinking skills are associated with misconception reduction (Kowalski & Taylor, 2004; see also Hughes, Lyddy, & Lambe, 2013). In addition, it was argued that critical thinking instruction effectively increases metacognitive monitoring accuracy (Bensely & Lilienfeld, 2020), which could also play a role in identifying misconceptions.

The research findings from this dissertation also offer practical implications, particularly for university lecturers who design and deliver lectures to preservice teachers. First, this dissertation showed that German preservice teachers endorse educational psychological misconceptions. If university lecturers know about the misconceptions that preservice teachers bring to class, these lecturers can adapt their teaching accordingly. Once the abovementioned inventory that measures different educational psychological misconceptions has been developed, lecturers should consider using it in their educational psychology classes to assess the misconceptions students bring to the lecture. Second, it has been argued that especially lecturers for educational psychology can be role models in implementing EBT by applying research knowledge from their own field to their own practice (see, e.g., Dunn et al., 2013; Dutke et al., 2017). Our research results showed that refutations are effective at reducing preservice teachers' educational psychological misconceptions. Therefore, university lecturers should develop refutations (e.g., texts, videos, slides) and incorporate them into their lectures to cover the topics about which their students endorse misconceptions and to additionally foster EBT. Also on a metalevel, lecturers could then reflect on refutation teaching with their students, thus making it more likely that they will use refutation approaches in their classroom when they become teachers themselves (e.g., to target misconceptions about evolution in biology classes).

Third, a large proportion of misconceptions were attributed to scientific sources, mainly lectures. Even though we could not verify whether these retrospectively self-reported sources were the real sources of preservice teachers' misconceptions about specific educational psychological topics, this finding still contains practical relevance: It could either be the case that lecturers taught content that was or became out of date, thus leading to a current misconception. This could particularly be the case for the misconception about the effectiveness of different learning styles because a previously published review showed that, in higher education, the use of learning styles is booming (Newton, 2015), a finding that can be interpreted to mean that higher education teachers believe in the effectiveness of learning styles

and, hence, present them as useful for teaching effectiveness. However, for further topics, it is more likely that preservice teachers misunderstood the content that was taught in lectures or erroneously attributed their knowledge acquisition to a lecture. Alarmingly, these misconceptions could even be endorsed to a greater extent because preservice teachers might think they got their knowledge from a valuable source. Therefore, lecturers need to make sure that preservice teachers do not leave their educational psychology classes with (more) misconceptions about the topics covered in class. Again, this can be achieved by using an appropriate tool to investigate educational psychological misconceptions as well as refutation approaches to reduce these misconceptions as much as possible. However, this is only the first step toward achieving a situation in which preservice teachers endorse as few misconceptions as possible; of course, they also need to be encouraged to further engage with scientific literature and stay up-to-date regarding relevant topics for their (future) careers. To achieve this, a positive attitude toward research could be supportive and should therefore also be fostered in teacher education.

8. General Conclusion

This dissertation falls into the so-called post-truth era (e.g., Laybats & Tredinnick, 2016; Lewandowsky et al., 2017; Sismondo, 2017) and focuses on a closely related issue, that is, beliefs in incorrect and popular assumptions that often stem from common sense, the media, or personal experience (see, e.g., Bensley & Lilienfeld, 2015, 2017; Hughes, Lyddy, & Lambe, 2013; Taylor & Kowalski, 2004). Regarding the specific area of education, I reasoned about the importance of EBT (see Bauer & Prenzel, 2012; Borg, 2010; Commission of the European Communities, 2007; KMK, 2004) and (preservice) teachers' preference for anecdotal information (e.g., Allen, 2009; Bråten, & Ferguson, 2015; Gitlin et al., 1999; Schildkamp & Kuiper, 2010). One particular obstacle to achieving evidence-based thinking and acting in (preservice) teachers is their endorsement of educational psychological misconceptions because

such incorrect beliefs directly stand in contrast to research findings from the field of educational psychology and often stem from personal experience. Therefore, to achieve EBT, it is important to focus on (preservice) teachers' educational psychological misconceptions, where they come from, and how to reduce them effectively and persistently. When I began working on this dissertation, research on specific educational psychological misconceptions that went beyond preservice teachers' beliefs in neuromyths was still scarce. Now, toward the end of this project, several authors have published research findings on preservice teachers' educational psychological misconceptions assessed in different countries (e.g., Asberger et al., 2020; Eitel et al., 2019; Pieschl et al., 2019), indicating the rising importance of this research topic.

The detrimental influence of psychological misconceptions has been discussed widely, including, for example, hindering future learning of psychological topics (see, e.g., Hughes, Lyddy, & Lambe, 2013). Transferring this knowledge to (preservice) teachers exemplifies the enormous threat of such misconceptions: If preservice teachers enter educational psychology classes with misconceptions about topics they will learn about in class, their understanding of these topics could be negatively influenced by their pre-existing but incorrect assumptions. Even though educational psychology plays a role in teacher education (see, e.g., Dutke et al., 2016; Patrick et al., 2011), there are often only a few courses implemented in the program, leading to the high importance of targeting existing educational psychological misconceptions in each of these courses. On a personal level, the endorsement of misconceptions leads to worse learning outcomes. On a societal level, the endorsement of misconceptions hinders the implementation of EBT, thus hindering the opportunity to teach young people with the best methods available. This second aspect also emphasizes the importance of why (preservice) teachers in particular need to be prevented or rectified from endorsing educational psychological misconceptions: Teachers have a strong influence on different people and tasks, and they are role models (see Commission of the European Communities, 2007), leading to the conclusion that their thinking and acting impacts a large proportion of society. Taken together,

if teachers in class act in accordance with the current state of research (i.e., when their actions are not based on misconceptions), they can achieve several goals: First, they will act in accordance with teaching standards (see Commission of the European Communities, 2007; KMK, 2004), second, they will use the best available evidence to inform their practice (i.e., EBT), and third, they will not transmit unsupported information, and therefore, they will prevent a snowball system of distributing misconceptions. Especially for this last aspect, achieving a high level of metacognitive monitoring accuracy is particularly important for (preservice) teachers to be able to distinguish what they know from what they do not know (yet).

This dissertation contributes to an important and rising topic of research by investigating large and diverse samples of German preservice teachers, bringing the prevalence and origins of various educational psychological misconceptions among them to the surface, and testing different approaches that can be applied to reduce these misconceptions in both experimental online settings and quasi-experimental real-life settings. Although the three empirical studies described above yielded significant and interesting results regarding preservice teachers' educational psychological misconceptions, there is still the potential to conduct further research in this area. The behavioral consequences of misconception endorsement should be the focus of future studies to investigate and ideally prevent the direct consequences of (preservice) teachers' misconceptions on their students. By doing so, the implementation of EBT, and thus, the improvement of teaching and learning, can be supported further.

References

Afdal, H. W., & Spernes, K. (2018). Designing and redesigning research-based teacher education. *Teaching and Teacher Education, 74*, 215–228. https://doi.org/10.1016/j.tate.2018.05.011

Aguilar, S. J., Polikoff, M. S., & Sinatra, G. M. (2019). Refutation texts: A new approach to changing public misconceptions about education policy. *Educational Researcher, 48*(5), 263–272. https://doi.org/10.3102/0013189X19849416

Allen, J. M. (2009). Valuing practice over theory: How beginning teachers re-orient their practice in the transition from the university to the workplace. *Teaching and Teacher Education, 25*(5), 647–654. https://doi.org/10.1016/j.tate.2008.11.011

Asberger, J., Thomm, E., & Bauer, J. (2020). Zur Erfassung fragwürdiger Überzeugungen zu Bildungsthemen: Entwicklung und erste Überprüfung des Questionable Beliefs in Education-Inventars (QUEBEC) [What misconceptions do preservice teachers hold about core educational topics? Development and psychometric analysis of the Questionable Beliefs in Education Inventory (QUEBEC)]. *Psychologie in Erziehung und Unterricht, 67*, 178–193. https://doi.org/10.2378/peu2019.art25d

Baan, J., Gaikhorst, L., van 't Noordende, J., & Volman, M. (2019). The involvement in inquiry-based working of teachers of research-intensive versus practically oriented teacher education programs. *Teaching and Teacher Education, 84*, 74–82. https://doi.org/10.1016/j.tate.2019.05.001

Barenberg, J., & Dutke, S. (2013). Metacognitive monitoring in university classes: Anticipating a graded vs. a pass-fail test affects monitoring accuracy. *Metacognition and Learning, 8*(2), 121–143. https://doi.org/10.1007/s11409-013-9098-3

Barzilai, S., & Chinn, C. A. (2020). A review of educational responses to the "post-truth" condition: Four lenses on "post-truth" problems. *Educational Psychologist, 55*(3), 107–119. https://doi.org/10.1080/00461520.2020.1786388

Bauer, J., & Prenzel, M. (2012). European teacher training reforms. *Science Education, 336*(6089), 1642–1643. https://doi.org/10.1126/science.1218387

Bauer, J., Prenzel, M., & Renkl, A. (2015). Evidenzbasierte Praxis – im Lehrerberuf?! Einführung in den Thementeil [Evidence-based practice in teaching?! Introduction to the special issue]. *Unterrichtswissenschaft, 43*(3), 188–192. http://www.digizeitschriften.de/dms/resolveppn/?PID=PPN513613439_0043|LOG_0029

Bayraktar, S. (2009). Misconceptions of Turkish preservice teachers about force and motion. *International Journal of Science and Mathematics Education, 7*(2), 273–291. https://doi.org/10.1007/s10763-007-9120-9

Bensley, D. A., & Lilienfeld, S. O. (2015). What is a psychological misconception? Moving toward an empirical answer. *Teaching of Psychology, 42*(4), 282–292. https://doi.org/10.1177/0098628315603059

Bensley, D. A., & Lilienfeld, S. O. (2017). Psychological misconceptions: Recent scientific advances and unresolved issues. *Current Directions in Psychological Science, 26*(4), 377–382. https://doi.org/10.1177/0963721417699026

Bensley, D. A., & Lilienfeld, S. O. (2020). Assessing belief in unsubstantiated claims. *Scholarship of Teaching and Learning in Psychology, 6*(3), 198–211. https://doi.org/10.1037/stl0000218

Bensley, D. A., Lilienfeld, S. O., & Powell, L. A. (2014). A new measure of psychological misconceptions: Relations with academic background, critical thinking, and acceptance

of paranormal and pseudoscientific claims. *Learning and Individual Differences, 36,* 9–18. https://doi.org/10.1016/j.lindif.2014.07.009

Bensley, D. A., Rainey, C., Lilienfeld, S. O., & Kuehne, S. (2015). What do psychology students know about what they know in psychology? *Scholarship of Teaching and Learning in Psychology, 1*(4), 283–297. https://doi.org/10.1037/stl0000035

Berliner, D. C. (2002). Educational research: The hardest science of all. *Educational Researcher, 31*(8), 18–20. https://doi.org/10.3102/0013189X031008018

Biesta, G. (2007). Why "what works" won't work: Evidence-based practice and the democratic deficit in educational research. *Educational Theory, 57*(1), 1–22. https://doi.org/10.1111/j.1741-5446.2006.00241.x

Blanchette Sarrasin, J., Riopel, M., & Masson, S. (2019). Neuromyths and their origin among teachers in Quebec. *Mind, Brain, and Education, 13*(2), 100–109. https://doi.org/10.1111/mbe.12193

Borg, S. (2010). Language teacher research engagement. *Language Teaching, 43*(4), 391–429. https://doi.org/10.1017/S0261444810000170

Braasch, J. L. G., Goldman, S. R., & Wiley, J. (2013). The influences of text and reader characteristics on learning from refutations in science texts. *Journal of Educational Psychology, 105*(3), 561–578. https://doi.org/10.1037/a0032627

Bråten, I., & Ferguson, L. E. (2015). Beliefs about sources of knowledge predict motivation for learning in teacher education. *Teaching and Teacher Education, 50,* 13–23. https://doi.org/10.1016/j.tate.2015.04.003

Brew, A., & Saunders, C. (2020). Making sense of research-based learning in teacher education. *Teaching and Teacher Education, 87*, 1–11. https://doi.org/10.1016/j.tate.2019.102935

Brinthaupt, T. M., Hurst, J. R., & Johnson, Q. R. (2016). Psychology degree beliefs and stereotypes: Differences in the perceptions of majors and non-majors. *Psychology Learning & Teaching, 15*(1), 77–93. https://doi.org/10.1177/1475725716642116

Broekkamp, H., & van Hout-Wolters, B. (2007). The gap between educational research and practice: A literature review, symposium, and questionnaire. *Educational Research and Evaluation, 13*(3), 203–220. https://doi.org/10.1080/13803610701626127

Bromme, R., Prenzel, M., & Jäger, M. (2014). Empirische Bildungsforschung und evidenzbasierte Bildungspolitik [Educational research and evidence based educational policy]. *Zeitschrift für Erziehungswissenschaft, 17*(4), 3–54. https://doi.org/10.1007/s11618-014-0514-5

Broughton, S. H., Sinatra, G. M., & Reynolds, R. E. (2010). The nature of the refutation text effect: An investigation of attention allocation. *Journal of Educational Research, 103*(6), 407–423. https://doi.org/10.1080/00220670903383101

Buehl, M. M., & Fives, H. (2009). Exploring teachers' beliefs about teaching knowledge: Where does it come from? Does it change? *Journal of Experimental Education, 77*(4), 367–407. https://doi.org/10.3200/JEXE.77.4.367-408

Butler, J., Mooney Simmie, G., & O'Grady, A. (2015) An investigation into the prevalence of ecological misconceptions in upper secondary students and implications for preservice teacher education. *European Journal of Teacher Education, 38*(3), 300–319. https://doi.org/10.1080/02619768.2014.943394

Cain, T. (2016). Research utilisation and the struggle for the teacher's soul: A narrative review. *European Journal of Teacher Education, 39*(5), 616–629. https://doi.org/10.1080/02619768.2016.1252912

Chew, S. L. (2006). Seldom in doubt but often wrong: Addressing tenacious student misconceptions. In D. S. Dunn & S. L. Chew (Eds.), *Best practices for teaching introduction to psychology* (pp. 211–224). Lawrence Erlbaum Associates.

Clark, C. M. (1988). Asking the right questions about teacher preparation: Contributions of research on teacher thinking. *Educational Researcher, 17*(2), 5–12. https://doi.org/10.3102/0013189X017002005

Commission of the European Communities (2007). *Communication from the commission to the council and the European parliament. Improving the quality of teacher education.* Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52007DC0392

Cook, J., Ecker, U. K. H., & Lewandowsky, D. (2015). Misinformation and how to correct it. In R. A. Scott & S. M. Kosslyn (Eds.), *Emerging trends in the social and behavioural sciences* (pp. 1–17). John Wiley & Sons.

Costa, N., Marques, L., & Kempa, R. (2000). Science teachers' awareness of findings from education research. *Research in Science & Technological Education, 18*(1), 37–44. https://doi.org/10.1080/713694955

Cranney, J. (2013). Toward psychological literacy: A snapshot of evidence-based learning and teaching. *Australian Journal of Psychology, 65*(1), 1–4. https://doi.org/10.1111/ajpy.12013

Csanadi, A., Kollar, I., & Fischer, F. (2021). Pre-service teachers' evidence-based reasoning during pedagogical problem-solving: Better together? *European Journal of Psychology of Education, 36*(1), 147–168. https://doi.org/10.1007/s10212-020-00467-4

Dagenais, C., Lysenko, L., Abrami, P. C., Bernard, R. M., Ramde, J., & Janosz, M. (2012). Use of research-based information by school practitioners and determinants of use: A review

of empirical research. *Evidence & Policy, 8*(3), 285–309. https://doi.org/10.1332/174426412X654031

Danielson, R. W., Sinatra, G. M., & Kendeou, P. (2016). Augmenting the refutation text effect with analogies and graphics. *Discourse Processes, 53*(5-6), 392–414. https://doi.org/10.1080/0163853X.2016.1166334

Davies, P. (1999). What is evidence-based education? *British Journal of Educational Studies, 47*(2), 108–121. https://doi.org/10.1111/1467-8527.00106

de Bruyckere, P., Kirschner, P. A., & Hulshof, C. D. (2015). *Urban myths about learning and education*. Elsevier.

Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology, 3*, Article 429. https://doi.org/10.3389/fpsyg.2012.00429

Delaney, P. F., Verkoeijen, P. P. J. L., & Spirgel, A. (2010). Spacing and the testing effects: A deeply critical, lengthy, and at times discursive review of the literature. *Psychology of Learning and Motivation, 53*, 63–147. https://doi.org/10.1016/S0079-7421(10)53003-2

Dündar, S., & Gündüz, N. (2016). Misconceptions regarding the brain: The neuromyths of preservice teachers. *Mind, Brain, and Education, 10*(4), 212–232. https://doi.org/10.1111/mbe.12119

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest, 14*(1), 4–58. https://doi.org/10.1177/1529100612453266

Dunn, D. S., Saville, B. K., Baker, S. C., & Marek, P. (2013). Evidence-based teaching: Tools and techniques that promote learning in the psychology classroom. *Australian Journal of Psychology, 65*(1), 5–13. https://doi.org/10.1111/ajpy.12004

Dunning, D. (2011). The Dunning-Kruger effect: On being ignorant of one's own ignorance. In J. M. Olson & M. P. Zanna (Eds.), *Advances in Experimental Social Psychology, Vol. 44* (pp. 247–296). Academic Press. https://doi.org/10.1016/B978-0-12-385522-0.00005-6

Dutke, S., Bakker, H. E., Papageorgi, I., & Taylor, J. (2017). PLAT 16(2) 2017: Introduction to the special issue on evidence-based teaching (EBT): Examples from learning and teaching psychology. *Psychology Learning & Teaching, 16*(2), 175–178. https://doi.org/10.1177/1475725717701209

Dutke, S., & Barenberg, J. (2009). Ökonomisch anwendbare Wissenstests für teilnehmerreiche Psychologieveranstaltungen [Economic knowledge tests for large psychology courses]. In M. Krämer, S. Preiser, & K. Brusdeylins (Eds.), *Psychologiedidaktik und Evaluation VII [Didactics of psychology and evaluation VII]* (pp. 367–376). Shaker.

Dutke, S., Koepcke, L., & Souvignier, E. (2016). Beiträge der Psychologie zum Praxissemester in der Lehramtsausbildung [Contributions of psychology to the practical semester in teacher training]. In M. Krämer, S. Preiser, & K. Brusdeylins (Eds.), *Psychologiedidaktik und Evaluation XI [Didactics of psychology and evaluation XI]* (pp. 61–69). Shaker.

Ecker, U. K. H., O'Reilly, Z., Reid, J. S., & Chang, E. P. (2020). The effectiveness of short-format refutational fact-checks. *British Journal of Psychology, 111*(1), 36–54. https://doi.org/10.1111/bjop.12383

Eitel, A., Dersch, A.-S., & Renkl, A. (2019). Wissenschaftliche Annahmen und Fehlkonzepte angehender Lehrkräfte über das Lernen mit Multimedia [Pre-service teachers' knowledge and misconceptions of learning with multimedia]. *Unterrichtswissenschaft, 47*(4), 451–474. https://doi.org/10.1007/s42010-019-00049-4

Emmons, M., Keefe, E. B., Moore, V. M., Sanchez, R. M., Mals, M. M., & Neely, T. Y. (2009). Teaching information literacy skills to prepare teachers who can bridge the research-to-practice gap. *Reference & User Services Quarterly, 49*(2), 140–150. https://doi.org/10.5860/rusq.49n2.140

Fazio, L. K., Dolan, P. O., & Marsh, E. J. (2015). Learning misinformation from fictional sources: Understanding the contributions of transportation and item-specific processing. *Memory, 23*(2), 167–177. https://doi.org/10.1080/09658211.2013.877146

Feinstein, N. W., & Waddington, D. I. (2020). Individual truth judgments or purposeful, collective sensemaking? Rethinking science education's response to the post-truth era. *Educational Psychologist, 55*(3), 155–166. https://doi.org/10.1080/00461520.2020.1780130

Ferrero, M., Garaizar, P., & Vadillo, M. A. (2016). Neuromyths in education: Prevalence among Spanish teachers and an exploration of cross-cultural variation. *Frontiers in Human Neuroscience, 10*, Article 496. https://doi.org/10.3389/fnhum.2016.00496

Ferrero, M., Hardwicke, T. E., Konstantinidis, E., & Vadillo, M. A. (2020). The effectiveness of refutation texts to correct misconceptions among educators. *Journal of Experimental Psychology: Applied, 26*(3), 411–421. https://doi.org/10.1037/xap0000258

Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., Neuhaus, B., Dorner, B., Pankofer, S., Fischer, M., Strijbos, J.-W., Heene, M., & Eberle, J. (2014). Scientific reasoning and argumentation: Advancing an interdisciplinary research agenda in

education. *Frontline Learning Research, 2*(3), 28–45. https://doi.org/10.14786/flr.v2i2.96

Flood, A. (2016). *'Post-truth' named word of the year by Oxford Dictionaries*. Retrieved from https://www.theguardian.com/books/2016/nov/15/post-truth-named-word-of-the-year-by-oxford-dictionaries

Francek, M. (2013) A compilation and review of over 500 Geoscience misconceptions. *International Journal of Science Education, 35*(1), 31–64. https://doi.org/10.1080/09500693.2012.736644

Furnham, A. (2018). Myths and misconceptions in developmental and neuro-psychology. *Psychology, 9*(2), 249–259. https://doi.org/10.4236/psych.2018.92016

Furnham, A., Callahan, I., & Rawles, R. (2003). Adults' knowledge of general psychology. *European Psychologist, 8*(2), 101–116. https://doi.org/10.1027//1016-9040.8.2.101

Furnham, A., & Hughes, D. J. (2014). Myths and misconceptions in popular psychology: Comparing psychology students and the general public. *Teaching of Psychology, 41*(3), 256–261. https://doi.org/10.1177/0098628314537984

Gardner, R. M., & Brown, D. L. (2013). A test of contemporary misconceptions in psychology. *Learning and Individual Differences, 24*, 211–215. https://doi.org/10.1016/j.lindif.2012.12.008

Gardner, R. M., & Dalsing, S. (1986). Misconceptions about psychology among college students. *Teaching of Psychology, 13*(1), 32–34. https://doi.org/10.1207/s15328023top1301_9

Gaze, C. M. (2014). Popular psychological myths: A comparison of students' beliefs across the psychology major. *Journal of the Scholarship of Teaching and Learning, 14*(2), 46–60. https://doi.org/10.14434/josotl.v14i2.3931

Gilovich, T. (1991). *How we know what isn't so: The fallibility of human reason in everyday life*. Free Press.

Gitlin, A., Barlow, L., Burbank, M. D., Kauchak, D., & Stevens, T. (1999). Preservice teachers' thinking on research: Implications for inquiry oriented teacher education. *Teaching and Teacher Education, 15*(7), 753–769. https://doi.org/10.1016/S0742-051X(99)00015-3

Glass, L., Bartels, J. M., Ryan, J. J., & Stark-Wroblewski, K. (2008). The effectiveness of psychology courses at disconfirming common psychological myths. *Individual Differences Research, 6*(2), 97–103.

Gleichgerrcht, E., Lira Luttges, B., Salvarezza, F., & Campos, A. L. (2015). Educational neuromyths among teachers in Latin America. *Mind, Brain, and Education, 9*(3), 170–178. https://doi.org/10.1111/mbe.12086

Groccia, J. E., & Buskist, W. (Eds.). (2011). Need for evidence-based teaching. In W. Buskist & J. E. Groccia (Eds.), *Evidence-based teaching: New directions in teaching and learning* (pp. 5–11). Jossey-Bass.

Grospietsch, F., & Mayer, J. (2018). Professionalizing preservice biology teachers' misconceptions about learning and the brain through conceptual change. *Education Sciences, 8*(120), 1–23. https://doi.org/10.3390/educsci8030120

Gutman, A. (1979). Misconceptions of psychology and performance in the introductory course. *Teaching of Psychology, 6*(3), 159–161. https://doi.org/10.1207/s15328023top0603_9

Guzzetti, B. J. (2000). Learning counter-intuitive science concepts: What have we learned from over a decade of research? *Reading and Writing Quarterly, 16*(2), 89–98. https://doi.org/10.1080/105735600277971

Guzzetti, B. J., Snyder, T. E., Glass, G. V., & Gamas, W. W. (1993). Promoting conceptual change in science: A comparative meta-analysis of interventions from reading education

and science education. *Reading Research Quarterly, 28*(2), 116–159. https://doi.org/10.2307/747886

Guzzetti, B. J., Williams, W. O., Skeels, S. A., &Wu, S. M. (1997). Influence of text structure on learning counterintuitive physics concepts. *Journal of Research in Science Teaching, 34*(7), 701–719. https://doi.org/10.1002/(SICI)1098-2736(199709)34:7<701::AID-TEA3>3.0.CO;2-Q

Händel, M., Harder, B., & Dresel, M. (2020). Enhanced monitoring accuracy and test performance: Incremental effects of judgment training over and above repeated testing. *Learning and Instruction, 65*, 1–9. https://doi.org/10.1016/j.learninstruc.2019.101245

Hargreaves, D. H. (2000). Teaching as a research-based profession: Possibilities and prospects. In B. Moon, J. Butcher, & E. Bird (Eds.), *Leading professional development in education* (pp. 200–210). RoutledgeFalmer.

Hartmann, U., Decristan, J., & Klieme, E. (2016). Unterricht als Feld evidenzbasierter Bildungspraxis? Herausforderungen und Potenziale für einen wechselseitigen Austausch von Wissenschaft und Schulpraxis [Evidence-based teaching? Opportunities and challenges for exchange between research and practice]. *Zeitschrift für Erziehungswissenschaft, 19*(1), 179–199. https://doi.org/10.1007/s11618-016-0712-4

Hendriks, F., Seifried, E., & Menz, C. (2021). Unraveling the "smart but evil" stereotype: Pre-service teachers' evaluations of educational psychology researchers versus teachers as sources of information. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000300

Hermida, M. J., Segretin, M. S., Soni García, A., & Lipina, S. J. (2016). Conceptions and misconceptions about neuroscience in preschool teachers: A study from Argentina.

Educational Research, 58(4), 457–472. https://doi.org/10.1080/00131881.2016.1238585

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force Concept Inventory. *The Physics Teacher, 30*(3), 141–158. https://doi.org/10.1119/1.2343497

Hetmanek, A., Wecker, C., Kiesewetter, J., Trempler, K., Fischer, M. R., Gräsel, C., & Fischer, F. (2015). Wozu nutzen Lehrkräfte welche Ressourcen? Eine Interviewstudie zur Schnittstelle zwischen bildungswissenschaftlicher Forschung und professionellem Handeln im Bildungsbereich [For what do teachers use which kind of resources? An interview study on the interface between research and professional practice in education]. *Unterrichtswissenschaft, 43*, 193–208. http://www.digizeitschriften.de/dms/resolveppn/?PID=PPN513613439_0043|LOG_0030

Higbee, K. L., & Clay, S. L. (1998). College students' beliefs in the ten-percent myth. *Journal of Psychology: Interdisciplinary and Applied, 132*(5), 469–476. https://doi.org/10.1080/00223989809599280

Horvath, J. C., Donoghue, G. M., Horton, A. J., Lodge, J. M., & Hattie, J. A. C. (2018). On the irrelevance of neuromyths to teacher effectiveness: Comparing neuro-literacy levels amongst award-winning and non-award winning teachers. *Frontiers in Psychology, 9*, Article 1666. https://doi.org/10.3389/fpsyg.2018.01666

Hughes, S., Lyddy, F., & Kaplan, R. (2013). The impact of language and response format on student endorsement of psychological misconceptions. *Teaching of Psychology, 40*(1), 31–37. https://doi.org/10.1177/0098628312465861

Hughes, S., Lyddy, F., Kaplan, R., Nichols, A. L., Miller, H., Saad, C. G., Dukes, K., & Lynch, A.-J. (2015). Highly prevalent but not always persistent: Undergraduate and graduate

student's misconceptions about psychology. *Teaching of Psychology, 42*(1), 34–42. https://doi.org/10.1177/0098628314562677

Hughes, S., Lyddy, F., & Lambe, S. (2013). Misconceptions about psychological science: A review. *Psychology Learning & Teaching, 12*(1), 20–31. https://doi.org/10.2304/plat.2013.12.1.20

Hynd, C. R. (2001). Refutational texts and the change process. *International Journal of Educational Research, 35*(7-8), 699–714. https://doi.org/10.1016/S0883-0355(02)00010-1

Ingram, D., Seashore Louis, K., & Schroeder, R. G. (2004). Accountability policies and teacher decision making: Barriers to the use of data to improve practice. *Teachers College Record, 106*(6), 1258–1287. https://doi.org/10.1111/j.1467-9620.2004.00379.x

Kagan, D. M. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*(2), 129–169. https://doi.org/10.2307/1170578

Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C. (2016). Identifying preservice physics teachers' misconceptions and conceptual difficulties about geometrical optics. *European Journal of Physics, 37*(4), 1–30. https://doi.org/10.1088/0143-0807/37/4/045705

Kendeou, P., Braasch, J. L. G., & Bråten, I. (2016). Optimizing conditions for learning: Situating refutations in epistemic cognition. *Journal of Experimental Education, 84*(2), 245–263. https://doi.org/10.1080/00220973.2015.1027806

Kendeou, P., Butterfuss, R., Kim, J., & van Boekel, M. (2019). Knowledge revision through the lenses of the three-pronged approach. *Memory & Cognition, 47*(1), 33–46. https://doi.org/10.3758/s13421-018-0848-y

Kendeou, P., Smith, E. R., & O'Brien, E. J. (2013). Updating during reading comprehension: Why causality matters. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(3), 854–865. https://doi.org/10.1037/a0029468

Kendeou, P., & van den Broek, P. (2007). The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. *Memory & Cognition, 35*(7), 1567–1577. https://doi.org/10.3758/BF03193491

Kendeou, P., Walsh, E. K., Smith, E. R., & O'Brien, E. J. (2014). Knowledge revision processes in refutation texts. *Discourse Processes, 51*(5-6), 374–397. https://doi.org/10.1080/0163853X.2014.913961

Kiemer, K., & Kollar, I. (2021). Source selection and source use as a basis for evidence-informed teaching: Do pre-service teachers' beliefs regarding the utility of (non-)scientific information sources matter? *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000302

Klein, M., Wagner, K., Klopp, E., & Stark, R. (2015). Förderung anwendbaren bildungswissenschaftlichen Wissens bei Lehramtsstudierenden anhand fehlerbasierten kollaborativen Lernens: Eine Studie zur Replikation bisheriger Befunde sowie zur Nachhaltigkeit und Erweiterung der Trainingsmaßnahmen [Fostering of applicable educational knowledge in student teachers by error-based collaborative learning: A study on the replication of earlier results and extension of the training]. *Unterrichtswissenschaft, 43*(3), 225–244. http://www.digizeitschriften.de/dms/resolveppn/?PID=PPN513613439_0043|LOG_0032

Kultusministerkonferenz. (2004). *Standards für die Lehrerbildung: Bildungswissenschaften. Beschluss der Kultusministerkonferenz* [*Standards for teacher education. Decision of the Conference of the Ministers of Education and Cultural Affairs*]. KMK.

Korthagen, F. A. J. (2007). The gap between research and practice revisited. *Educational Research and Evaluation, 13*(3), 303–310. https://doi.org/10.1080/13803610701640235

Kowalski, P., & Taylor, A. K. (2004). Ability and critical thinking as predictors of change in students' psychological misconceptions. *Journal of Instructional Psychology, 31*(4), 297–303.

Kowalski, P., & Taylor, A. K. (2009). The effect of refuting misconceptions in the introductory psychology class. *Teaching of Psychology, 36*(3), 153–159. https://doi.org/10.1080/00986280902959986

Kowalski, P., & Taylor, A. K. (2011). Effectiveness of refutational teaching for high- and low-achieving students. *Journal of the Scholarship of Teaching and Learning, 11*(1), 79–90.

Kowalski, P., & Taylor, A. K. (2017). Reducing students' misconceptions with refutational teaching: For long-term retention, comprehension matters. *Scholarship of Teaching and Learning in Psychology, 3*(2), 1–11. https://doi.org/10.1037/stl0000082

Krammer, G., Vogel, S. E., Yardimci, T., & Grabner, R. H. (2019). Neuromythen sind zu Beginn des Lehramtsstudiums prävalent und unabhängig vom Wissen über das menschliche Gehirn [Neuromyths are prevalent and independent of the knowledge of the human brain at the beginning of teacher education]. *Zeitschrift für Bildungsforschung, 9*(2), 221–246. https://doi.org/10.1007/s35834-019-00238-2

Kuhle, B. X., Barber, J. M., & Bristol, A. S. (2009). Predicting students' performance in introductory psychology from their psychology misconceptions. *Journal of Instructional Psychology, 36*(2), 119–124.

Labaree, D. F. (2003). The peculiar problems of preparing educational researchers. *Educational Researcher, 32*(4), 13–22. https://doi.org/10.3102/0013189X032004013

LaCaille, R. A., LaCaille, L. J., & Damsgard, E. (2019). Refuting mental health misconceptions: A quasi-experiment with abnormal psychology courses. *Psychology Learning & Teaching, 18*(3), 275–289. https://doi.org/10.1177/1475725719856269

Landau, J. D., & Bavaria, A. J. (2003). Does deliberate source monitoring reduce students' misconceptions about psychology? *Teaching of Psychology, 30*(4), 311–314.

Landrum, T. J., Cook, B. G., Tankersley, M., & Fitzgerald, S. (2002). Teacher perceptions of the trustworthiness, usability, and accessibility of information from different sources. *Remedial and Special Education, 23*(1), 42–48. https://doi.org/10.1177/074193250202300106

Landrum, T. J., Cook, B. G., Tankersley, M., & Fitzgerald, S. (2007). Teacher perceptions of the usability of intervention information from personal versus data-based sources. *Education and Treatment of Children, 30*(4), 27–42. https://doi.org/10.1353/etc.2007.0025

Lassonde, K. A., Kendeou, P., & O'Brien, E. J. (2016). Refutation texts: Overcoming psychology misconceptions that are resistant to change. *Scholarship of Teaching and Learning in Psychology, 2*(1), 62–74. https://doi.org/10.1037/stl0000054

Lassonde, K. A., Kolquist, M., & Vergin, M. (2017). Revising psychology misconceptions by integrating a refutation-style text framework into poster presentations. *Teaching of Psychology, 44*(3), 255–262. https://doi.org/10.1177/0098628317712754

Laybats, C., & Tredinnick, L. (2016). Post truth, information, and emotion. *Business Information Review, 33*(4), 204–206. https://doi.org/10.1177/0266382116680741

Lethaby, C., & Harries, P. (2016). Learning styles and teacher training: Are we perpetuating neuromyths? *ELT Journal, 70*(1), 16–27. https://doi.org/10.1093/elt/ccv051

Lewandowsky, S., Ecker, U. K. H., & Cook, J. (2017). Beyond misinformation: Understanding and coping with the "post-truth" era. *Journal of Applied Research in Memory and Cognition, 6*(4), 353–369. https://doi.org/10.1016/j.jarmac.2017.07.008

Lewandowsky, S., Ecker, U. K. H., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and its correction: Continued influence and successful debiasing. *Psychological Science in the Public Interest, 13*(3) 106–131. https://doi.org/10.1177/1529100612451018

Lilienfeld, S. O. (2005). Challenging mind myths in introductory psychology courses. *Psychology Teacher Network, 15*(3), 1–6.

Lilienfeld, S. O. (2010). Can psychology become a science? *Personality and Individual Differences, 49*(4), 281–288. https://doi.org/10.1016/j.paid.2010.01.024

Lilienfeld, S. O., Ammirati, R., & David, M. (2012). Distinguishing science from pseudoscience in school psychology: Science and scientific thinking as safeguards against human error. *Journal of School Psychology, 50*(1), 7–36. https://doi.org/10.1016/j.jsp.2011.09.006

Lilienfeld, S. O., Lynn, S. J., Ruscio, J., & Beyerstein, B. L. (2010). *50 great myths of popular psychology*. Wiley-Blackwell.

Lingard, B., & Renshaw, P. (2010). Teaching as a research-informed and research-informing profession. In A. Campbell & S. Groundwater-Smith (Eds.), *Connecting inquiry and*

professional learning in education: International perspectives and practical solutions (pp. 26–39). Routledge.

Lockie, S. (2017). Post-truth politics and the social sciences. *Environmental Sociology, 3*(1), 1–5. https://doi.org/10.1080/23251042.2016.1273444

Lyddy, F., & Hughes, S. (2012). Attitudes towards psychology as a science and the persistence of psychological misconceptions in psychology undergraduates. In V. Karandashev & S. McCarthy (Eds.), *Teaching psychology around the world* (Vol. 3, pp. 330–349). Cambridge Scholars Publishing.

Lysenko, L. V., Abrami, P. C., Bernard, R. M., Dagenais, C., & Janosz, M. (2014). Educational research in educational practice: Predictors of use. *Canadian Journal of Education / Revue canadienne de l'éducation, 37*(2), 1–26.

Macdonald, K., Germine, L., Anderson, A., Christodoulou, J., & McGrath, L. M. (2017). Dispelling the myth: Training in education or neuroscience decreases but does not eliminate beliefs in neuromyths. *Frontiers in Psychology, 8*, Article 1314. https://doi.org/10.3389/fpsyg.2017.01314

McCarthy, M. A., & Frantz, S. (2016). Challenging the status quo: Evidence that introductory psychology can dispel myths. *Teaching of Psychology, 43*(3), 211–214. https://doi.org/10.1177/0098628316649470

McCutcheon, L. E., Furnham, A., & Davis, G. (1993). A cross-national comparison of students' misconceptions about psychology. *Psychological Reports, 72*(1), 243–247. https://doi.org/10.2466/pr0.1993.72.1.243

McCutcheon, L. E., Hanson, E., Apperson, J. M., & Wynn, V. (1992). Relationships among critical thinking skills, academic achievement, and misconceptions about psychology. *Psychological Reports, 71*(2), 635–639. https://doi.org/10.2466/PR0.71.6.635-639

McDaniel, M. A., Anderson, J. L., Derbish, M. H., & Morrisette, N. (2007). Testing the testing effect in the classroom. *European Journal of Cognitive Psychology, 19*(4-5), 494–513. https://doi.org/10.1080/09541440701326154

McDaniel, M. A., Wildman, K. M., & Anderson, J. L. (2012). Using quizzes to enhance summative-assessment performance in a web-based class: An experimental study. *Journal of Applied Research in Memory and Cognition, 1*(1), 18–26. https://doi.org/10.1016/j.jarmac.2011.10.001

McIntyre, D. (2005). Bridging the gap between research and practice. *Cambridge Journal of Education, 35*(3), 357–382. https://doi.org/10.1080/03057640500319065

McKeachie, W. J. (1960). Changes in scores on the Northwestern Misconceptions Test in six elementary psychology courses. *Journal of Educational Psychology, 51*(4), 240–244. https://doi.org/10.1037/h0048569

Menz, C., Spinath, B., & Seifried, E. (2020). Misconceptions die hard: Prevalence and reduction of wrong beliefs in topics from educational psychology among preservice teachers. *European Journal of Psychology of Education*. Advance online publication. https://doi.org/10.1007/s10212-020-00474-5

Menz, C., Spinath, B., & Seifried, E. (2021). Where do pre-service teachers' educational psychological misconceptions come from? The roles of anecdotal versus scientific evidence. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000299.

Menz, C., Spinath, B., Hendriks, F., & Seifried, E. (in press). Reducing educational psychological misconceptions: How effective are standard lectures, refutation lectures, and instruction in information evaluation strategies? *Scholarship of Teaching and Learning in Psychology*.

Merk, S., & Rosman, T. (2019). Smart but evil? Student-teachers' perception of educational researchers' epistemic trustworthiness. *AERA Open, 5*(3), 1–18. https://doi.org/10.1177/2332858419868158

Merk, S., Rosman, T., Rueß, J., Syring, M., & Schneider, J. (2017). Pre-service teachers' perceived value of general pedagogical knowledge for practice: Relations with epistemic beliefs and source beliefs. *PLoS ONE, 12*(9), 1–25. https://doi.org/10.1371/journal.pone.0184971

National Board for Professional Teaching Practices. (2016). *What teachers should know and be able to do.* NBPTS.

Nehm, R., & Reilly, L. (2007). Biology majors' knowledge and misconceptions of natural selection. *BioScience, 57*(3), 263–272. https://doi.org/10.1641/B570311

Nelson, J., & Campbell, C. (2017). Evidence-informed practice in education: Meanings and applications. *Educational Research, 59*(2), 127–135. https://doi.org/10.1080/00131881.2017.1314115

Newton, P. M. (2015). The learning styles myth is thriving in higher education. *Frontiers in Psychology, 6*, Article 1908. https://doi.org/10.3389/fpsyg.2015.01908

Newton, P. M., & Miah, M. (2017). Evidence-based higher education – is the learning styles 'myth' important? *Frontiers in Psychology, 8*, Article 444. https://doi.org/10.3389/fpsyg.2017.00444

Newton, P. M., & Salvi, A. (2020). How common is belief in the learning styles neuromyth, and does it matter? A pragmatic systematic review. *Frontiers in Education, 5*, Article 602451. https://doi.org/10.3389/feduc.2020.602451

Niemi, H., & Nevgi, A. (2014). Research studies and active learning promoting professional competences in Finnish teacher education. *Teaching and Teacher Education, 43*, 131–142. https://doi.org/10.1016/j.tate.2014.07.006

Nussbaum, E. M., Cordova, J. R., & Rehmat, A. P. (2017). Refutation texts for effective climate change education. *Journal of Geoscience Education, 65*(1), 23–34. https://doi.org/10.5408/15-109.1

Organisation for Economic Development. (2005). *Teachers matter: Attracting, developing and retaining effective teachers*. OECD.

Oxford English Dictionary. (n.d.). Post-truth. In *Oxford English Dictionary*. Oxford University Press. https://www.oed.com/view/Entry/58609044?redirectedFrom=post-truth

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307–332. https://doi.org/10.2307/1170741

Papadatou-Pastou, M., Haliou, E., & Vlachos, F. (2017). Brain knowledge and the prevalence of neuromyths among prospective teachers in Greece. *Frontiers in Psychology, 8*, Article 804. https://doi.org/10.3389/fpsyg.2017.00804

Parr, J. M., & Timperley, H. S. (2008). Teachers, schools and using evidence: Considerations of preparedness. *Assessment in Education: Principles, Policy & Practice, 15*(1), 57–71. https://doi.org/10.1080/09695940701876151

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest, 9*(3), 105–119. https://doi.org/10.1111/j.1539-6053.2009.01038.x

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*(2), 89–96. https://doi.org/10.1111/j.1751-228X.2012.01141.x

Patrick, H., Anderman, L. H., Bruening, P. S., & Duffin, L. C. (2011). The role of educational psychology in teacher education: Three challenges for educational psychologists. *Educational Psychologist, 46*(2), 71–83. https://doi.org/10.1080/00461520.2011.538648

Pei, X., Howard-Jones, P. A., Zhang, S., Lui, X., & Jin, Y. (2015). Teachers' understanding about the brain in East China. *Social and Behavioral Sciences, 174*, 3681–3688. https://doi.org/10.1016/j.sbspro.2015.01.1091

Pendry, A., & Husbands, C. (2000). Research and practice in history teacher education. *Cambridge Journal of Education, 30*(3), 321–334. https://doi.org/10.1080/03797720600625275

Peters, M. A. (2017). Education in a post-truth world. *Educational Philosophy and Theory, 49*(6), 563–566. https://doi.org/10.1080/00131857.2016.1264114

Pieschl, S., Archer, J., & Budd, J. (2019, April 5-9). *Raising student teachers' awareness of their misconception regarding educational psychology* [Poster presentation]. Annual Meeting of the American Educational Research Association (AERA), Toronto, Canada.

Prinz, A., Golke, S., & Wittwer, J. (2019). Refutation texts compensate for detrimental effects of misconceptions on comprehension and metacomprehension accuracy and support transfer. *Journal of Educational Psychology, 111*(6), 957–981. https://doi.org/10.1037/edu0000329

Profetto-McGrath, J. (2005). Critical thinking and evidence-based practice. *Journal of Professional Nursing, 21*(6), 364–371. https://doi.org/10.1016/j.profnurs.2005.10.002

Rato, J. R., Abreu, A. M., & Castro-Caldas, A. (2013). Neuromyths in education: What is fact and what is fiction for Portuguese teachers? *Educational Research, 55*(4), 441–453. https://doi.org/10.1080/00131881.2013.844947

Roediger, H. L., III, Putnam, A. L., & Smith, M. A. (2011). Ten benefits of testing and their applications to educational practice. *Psychology of Learning and Motivation, 55*, 1–36. https://doi.org/10.1016/B978-0-12-387691-1.00001-6

Roelle, J., Schmidt, E. M., Buchau, A., & Berthold, K. (2017). Effects of informing learners about the dangers of making overconfident judgments of learning. *Journal of Educational Psychology, 109*(1), 99–117. https://doi.org/10.1037/edu0000132

Rohrer, D., & Taylor, K. (2006). The effects of overlearning and distributed practice on the retention of mathematics knowledge. *Applied Cognitive Psychology, 20*(9), 1209–1224. https://doi.org/10.1002/acp.1266

Rosenberg, W. M., & Sackett, D. L. (1996). On the need for evidence-based medicine. *Therapie, 51*(3), 212–217.

Ryan, J., & McCrae, B. (2006). Assessing preservice teachers' mathematics subject knowledge. *Mathematics Teacher Education and Development, 7*, 72–89.

Sanna, L. J., Schwarz, N., & Stocker, S. L. (2002). When debiasing backfires: Accessible content and accessibility experiences in debiasing hindsight. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*(3), 497–502. https://doi.org/10.1037//0278-7393.28.3.497

Saville, B. K. (2010). Using evidence-based teaching methods to improve education. In S. A. Meyers & J. R. Stowell (Eds.), Essays from e-xcellence in teaching (pp. 48–54). (Vol. 9), Published on the Society for the Teaching of Psychology Web site. Retrieved from http://teachpsych.org/ebooks/eit2009/index.php

Scheeler, M. C., Budin, S., & Markelz, A. (2016). The role of teacher preparation in promoting evidence-based practice in schools. *Learning Disabilities: A Contemporary Journal, 14*(2), 171–187.

Schildkamp, K., & Kuiper, W. (2010). Data-informed curriculum reform: Which data, what purposes, and promoting and hindering factors. *Teaching and Teacher Education, 26*, 482–496. https://doi.org/10.1016/j.tate.2009.06.007

Schwartz, B. M., & Gurung, R. A. R. (Eds.). (2012). *Evidence-based teaching for higher education*. American Psychological Association. https://doi.org/10.1037/13745-000

Sciutto, M. J. (2015). ADHD knowledge, misconceptions, and treatment acceptability. *Journal of Attention Disorders, 19*(2), 91–98. https://doi.org/10.1177/1087054713493316

Sharples, J. (2013). *Evidence for the frontline*. Alliance for Useful Evidence [online]. Accessed December 11, 2020. https://www.alliance4usefulevidence.org/publication/evidence-for-the-frontline/

Sibicky, M., Klein, C. L., & Embrescia, E. (2020). Psychological misconceptions and their relation to students' lay beliefs of mind. *Teaching of Psychology*. Advance online publication. https://doi.org/10.1177/0098628320959925

Sinatra, G. M., & Broughton, S. H. (2011). Bridging reading comprehension and conceptual change in science education: The promise of refutation text. *Reading Research Quarterly, 46*(4), 374–393. https://doi.org/10.1002/RRQ.005

Sismondo, S. (2017). Post-truth? *Social Studies of Science 47*(1), 3–6. https://doi.org/10.1177/0306312717692076

Sjølie, E. (2014). The role of theory in teacher education: Reconsidered from a student teacher perspective. *Journal of Curriculum Studies, 46*(6), 729–750. https://doi.org/10.1080/00220272.2013.871754

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*(7), 15–21. https://doi.org/10.3102/0013189X031007015

Slavin, R. E. (2008). Perspectives on evidence-based research in education – what works? Issues in synthesizing educational program evaluations. *Educational Researcher, 37*(1), 5–14. https://doi.org/10.3102/0013189X08314117

Spinath, B., Antoni, C., Bühner, M., Elsner, B., Erdfelder, E., Fydrich, T., Gollwitzer M., Heinrichs, M., König, C. J., & Vaterrodt, B. (2018). Empfehlungen zur Qualitätssicherung in Studium und Lehre [Recommendations for quality management in higher education]. *Psychologische Rundschau, 69*(3), 183–192. https://doi.org/10.1026/0033-3042/a000408

Stark, R. (2017). Probleme evidenzbasierter bzw. -orientierter pädagogischer Praxis [Problems of evidence-based or rather evidence-oriented educational practice]. *Zeitschrift für Pädagogische Psychologie, 31*(2), 1–12. https://doi.org/10.1024/1010-0652/a000201

Stein, M., Larrabee, T. G., & Barman, C. R. (2008). A study of common beliefs and misconceptions in physical science. *Journal of Elementary Science Education, 20*(2), 1–11. https://www.jstor.org/stable/43156166

Stuart, C., & Thurlow, D. (2000). Making it their own: Preservice teachers' experiences, beliefs, and classroom practices. *Journal of Teacher Education, 51*(2), 113–121. https://doi.org/10.1177/002248710005100205

Tardif, E., Doudin, P.-A., & Meylan, N. (2015). Neuromyths among teachers and teacher students. *Mind, Brain, and Education, 9*(1), 50–59. https://doi.org/10.1111/mbe.12070

Taylor, A. K., & Kowalski, P. (2004). Naive psychological science: The prevalence, strength, and sources of misconceptions. *Psychological Record, 54*(1), 15–25. https://doi.org/10.1007/BF03395459

Taylor, A. K., & Kowalski, P. (2012). Students' misconceptions in psychology: How you ask matters…sometimes. *Journal of the Scholarship of Teaching and Learning, 12*(3), 62–77.

Taylor, A. K., & Kowalski, P. (2014). Student misconceptions: Where do they come from and what can we do? In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum* (pp. 259–273). American Psychological Association (Division 2).

Taylor, A. K., & Kowalski, P. (2019, April 5-9). The importance of refutational teaching in the classroom. In E. Seifried, & B. Spinath (Chairs), *Ask for evidence: Identifying, preventing and counteracting scientific and educational myths* [Symposium]. Annual Meeting of the American Educational Research Association (AERA), Toronto, Canada.

Thomm, E., Gold, B., Betsch, T., & Bauer, J. (2021). When preservice teachers' prior beliefs contradict evidence from educational research. *British Journal of Educational Psychology*. Advance online publication. https://doi.org/10.1111/bjep.12407

Tippett, C. D. (2010). Refutational text in science education: A review of two decades of research. *International Journal of Science and Mathematics Education, 8*(6), 951–970. https://doi.org/10.1007/s10763-010-9203-x

Tovazzi, A., Giovannini, S., & Basso, D. (2020). A new method for evaluating knowledge, beliefs, and neuromyths about the mind and brain among Italian teachers. *Mind, Brain, and Education, 14*(2), 187–198. https://doi.org/10.1111/mbe.12249

Trempler, K., Hetmanek, A., Wecker, C., Kiesewetter, J., Wermelt, M., Fischer, F., Fischer, M., & Gräsel, C. (2015). Nutzung von Evidenz im Bildungsbereich. Validierung eines Instruments zur Erfassung von Kompetenzen der Informationsauswahl und Bewertung von Studien [Using evidence in education. Validating an instrument for measuring

competencies of information selection and evaluation of research studies]. *Zeitschrift für Pädagogik, 61*, 144–166.

Trevors, G. J., Muis, K. R., Pekrun, R., Sinatra, G. M., & Winne, P. H. (2016). Identity and epistemic emotions during knowledge revision: A potential account for the backfire effect. *Discourse Processes, 53*(5-6), 339–370. https://doi.org/10.1080/0163853X.2015.1136507

U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse (2014, October). *Beginning Reading intervention report: Carbo Reading Styles Program*®. Retrieved from http://whatworks.ed.gov

van den Broek, P., & Kendeou, P. (2008). Cognitive processes in comprehension of science texts: The role of co-activation in confronting misconceptions. *Applied Cognitive Psychology, 22*(3), 335–351. https://doi.org/10.1002/acp.1418

Vanderlinde, R., & van Braak, J. (2010). The gap between educational research and practice: Views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*(2), 299–316. https://doi.org/10.1080/01411920902919257

van der Linden, W., Bakx, A., Ros, A., Beijaard, D., & Vermeulen, M. (2012). Student teachers' development of a positive attitude towards research and research knowledge and skills. *European Journal of Teacher Education, 35*(4), 401–419. https://doi.org/10.1080/02619768.2011.643401

van Ingen, S., & Ariew, S. (2015). Making the invisible visible: Preparing preservice teachers for first steps in linking research to practice. *Teaching and Teacher Education, 51*, 182–190. https://doi.org/10.1016/j.tate.2015.07.001

van Loon, M. H., Dunlosky, J., van Gog, T., van Merriënboer, J. J., & de Bruin, A. B. (2015). Refutations in science texts lead to hypercorrection of misconceptions held with high

confidence. *Contemporary Educational Psychology, 42*, 39–48. https://doi.org/10.1016/j.cedpsych.2015.04.003

van Schaik, P., Volman, M., Admiraal, W., & Schenke, W. (2018). Barriers and conditions for teachers' utilisation of academic knowledge. *International Journal of Educational Research, 90*, 50–63. https://doi.org/10.1016/j.ijer.2018.05.003

Vaughan, E. D. (1977). Misconceptions about psychology among introductory psychology students. *Teaching of Psychology, 4*(3), 138–141. https://doi.org/10.1207/s15328023top0403_9

Vaughn, A. R., & Robbins, J. R. (2017). Preparing preservice K-8 teachers for the public school: Improving evolution attitudes, misconceptions, and legal confusion. *Journal of College Science Teaching, 47*(2), 7–15. https://doi.org/10.2505/4/jcst17_047_02_7

Vosniadou, S., Lawson, M. J., Wyra, M., Van Deur, P., Jeffries, D., & Darmawan, G. N., I. (2020). Pre-service teachers' beliefs about learning and teaching and about the self-regulation of learning: A conceptual change perspective. *International Journal of Educational Research, 99*, Article 101495. https://doi.org/10.1016/j.ijer.2019.101495

Weingartner, K. M., & Masnick, A. M. (2019). Refutation texts: Implying the refutation of a scientific misconception can facilitate knowledge revision. *Contemporary Educational Psychology, 58*, 138–148. https://doi.org/10.1016/j.cedpsych.2019.03.004

Wenglein, S., Bauer, J., Heininger, S., & Prenzel, M. (2015). Kompetenz angehender Lehrkräfte zum Argumentieren mit Evidenz: Erhöht ein Training von Heuristiken die Argumentationsqualität? [Pre-service teachers' evidence-based argumentation competence: Can a training of heuristics improve argumentative quality?]. *Unterrichtswissenschaft, 43*(3), 209–224.

http://www.digizeitschriften.de/dms/resolveppn/?PID=PPN513613439_0043|LOG_0031

What Works Clearinghouse. (2020). *Standards Handbook, Version 4.1*. Retrieved from https://ies.ed.gov/ncee/wwc/Handbooks

Williams, D., & Coles, L. (2007). Evidence-based practice in teaching: An information perspective. *Journal of Documentation*, *63*(6), 812–835. https://doi.org/10.1108/00220410710836376

Yates, T. B., & Marek, E. A. (2014). Teachers teaching misconceptions: A study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evolution: Education and Outreach*, *7*(7), 1–18. https://doi.org/10.1186/s12052-014-0007-2

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

FAKULTÄT FÜR VERHALTENS- UND EMPIRISCHE KULTURWISSENSCHAFTEN

Promotionsausschuss der Fakultät für Verhaltens- und Empirische Kulturwissenschaften der Ruprecht-Karls-Universität Heidelberg
Doctoral Committee of the Faculty of Behavioural and Cultural Studies of Heidelberg University

Erklärung gemäß § 8 (1) c) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften
Declaration in accordance to § 8 (1) c) of the doctoral degree regulation of Heidelberg University, Faculty of Behavioural and Cultural Studies

Ich erkläre, dass ich die vorgelegte Dissertation selbstständig angefertigt, nur die angegebenen Hilfsmittel benutzt und die Zitate gekennzeichnet habe.
I declare that I have made the submitted dissertation independently, using only the specified tools and have correctly marked all quotations.

Erklärung gemäß § 8 (1) d) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften
Declaration in accordance to § 8 (1) d) of the doctoral degree regulation of Heidelberg University, Faculty of Behavioural and Cultural Studies

Ich erkläre, dass ich die vorgelegte Dissertation in dieser oder einer anderen Form nicht anderweitig als Prüfungsarbeit verwendet oder einer anderen Fakultät als Dissertation vorgelegt habe.
I declare that I did not use the submitted dissertation in this or any other form as an examination paper until now and that I did not submit it in another faculty.

Vorname Nachname
First name Family name Cordelia Menz

Datum, Unterschrift
Date, Signature 01. März 2021

Publications of the Publication-Based Dissertation

Paper 1

This is the published version of the article

Menz, Cordelia, Spinath, Birgit, & Seifried, Eva (2020). Misconceptions Die Hard: Prevalence and Reduction of Wrong Beliefs in Topics From Educational Psychology Among Preservice Teachers. *European Journal of Psychology of Education.* Advance online publication. https://doi.org/10.1007/s10212-020-00474-5

Misconceptions Die Hard: Prevalence and Reduction of Wrong Beliefs in Topics from Educational Psychology Among Preservice Teachers

European Journal of Psychology of Education

Cordelia Menz[a]*, Birgit Spinath[b], and Eva Seifried[c]

[a]Educational Psychology, Heidelberg University, Hauptstraße 47-51, 69117 Heidelberg, Germany, Cordelia.Menz@psychologie.uni-heidelberg.de

[b]Educational Psychology, Heidelberg University, Hauptstraße 47-51, 69117 Heidelberg, Germany, Birgit.Spinath@psychologie.uni-heidelberg.de

[c]Educational Psychology, Heidelberg University, Hauptstraße 47-51, 69117 Heidelberg, Germany, Eva.Seifried@psychologie.uni-heidelberg.de

* corresponding author

Funding. This research project was financially supported by the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (Az: 33-7533.-30-10/25/63) and by the Excellence Initiative of the German Federal Government and the state governments – Funding line Institutional Strategy (Zukunftskonzept): DFG project number ZUK 49/Ü ("Heidelberg: Realising the Potential of a Comprehensive University").

Current Themes of Research

CORDELIA MENZ is a PhD student for psychology in the field of educational psychology at Heidelberg University, Germany. Her research interests include higher education, teacher education and evidence-based thinking.

Most relevant publications in the field of Psychology of Education:

No previous publications

BIRGIT SPINATH is professor of Educational Psychology at Heidelberg University, Germany. Her research interests include learning and teaching in schools and in higher education, motivation as a prerequisite for and an outcome of education, teacher education and self-regulation in the context of learning and achievement. Currently she is the President of the German Psychological Society.

Most relevant publications in the field of Psychology of Education:

Weidinger, A.F., Steinmayr, R. & Spinath, B. (2019). Ability self-concept formation in elementary school: No dimensional comparison effects across time. *Developmental Psychology, 55*, 1005-1018.

Kriegbaum, K., Becker, N. & Spinath, B. (2018). The relative importance of intelligence and motivation as predictors of school achievement: a meta-analysis. *Educational Research Review, 25*, 120-148.

Spinath, B. & Steinmayr, R. (2012). The roles of competence beliefs and goal orientations for change in intrinsic motivation. *Journal of Educational Psychology, 104*, 1135-1148.

EVA SEIFRIED, PhD, is a research associate at the chair for Educational Psychology at Heidelberg University, Germany. Her research interests include learning and teaching in higher education, teacher education and evidence-based thinking.

Most relevant publications in the field of Psychology of Education:

Seifried, E., & Spinath, B. (in press). Using formative (self-)assessment to improve teaching and learning in educational psychology courses. In E. Landrum, C. Hakala, & S. Nolan (Eds.), *Assessment: Individual, Institutional, and International Approaches*. APA Books.

Seifried, E., Eckert, C., & Spinath, B. (2018). Optional learning opportunities: Who seizes them and what are the learning outcomes? *Teaching of Psychology, 45*, 246–250.

Seifried, E., Lenhard, W., & Spinath, B. (2016). Automatic essay assessment: Effects on students' acceptance and on learning-related characteristics. *Psihologija, 49*, 469–482.

Misconceptions Die Hard: Prevalence and Reduction of Wrong Beliefs in Topics from Educational Psychology Among Preservice Teachers

Abstract

Endorsement of educational psychological misconceptions among preservice teachers can be a threat for reaching educational goals. Therefore, it is of societal interest whether preservice teachers hold educational psychological misconceptions and, if they do, whether these misconceptions can be reduced through confrontation with empirical evidence. Prevalence and refutability of misconceptions were analyzed among $N = 937$ German preservice teachers who participated in an online-survey. Results indicated a high prevalence of educational psychological misconceptions but also the possibility of a reduction through refutation-style texts. However, only few preservice teachers shifted their opinions from (rather) endorsing a misconception to (rather) not endorsing it after reading the text. We conclude that educational psychological misconceptions are common among German preservice teachers and that merely presenting empirical evidence is insufficient to effectively counteract misconceptions. Future research should deepen the understanding of why and wherefrom these misconceptions occur and develop efficient interventions to counteract misconceptions among preservice teachers.

Keywords: educational psychology; evidence; misconceptions; preservice teachers; refutation

"Maybe this particular study shows this effect but I myself experienced it differently. Therefore, it can't be true and I don't believe this!". This is an exemplary statement typically made by preservice teachers who attend educational psychology lectures and who have just been confronted with the findings of empirical studies. This quotation indicates two disconcerting aspects: First, at least some preservice teachers seem to hold wrong beliefs about topics in educational psychology, mostly based on (personal) experiences. Second, their preexisting opinion does not seem to be changed through the presentation of empirical evidence. Educational psychological misconceptions among preservice teachers are both disadvantageous

for students' own learning and precarious for their future students' development. This is the case because incorrect knowledge can impede further knowledge and teachers might distribute their (incorrect) knowledge as well as not use scientific evidence to design their own lessons. It has been shown in different countries that preservice teachers endorse misconceptions about topics in educational psychology (e.g. Dekker, Lee, Howard-Jones and Jolles 2012; Dündar and Gündüz 2016). Therefore, the aim of this study is to empirically analyze to what extent preservice teachers in Germany endorse misconceptions about topics in educational psychology as well as whether they change their misconceptions after being informed about the current state of research in a refutational fashion. Furthermore, previous studies indicate that preservice teachers seem to prefer anecdotal over empirical evidence (e.g. Bråten and Ferguson 2015; Williams and Coles 2007) but these types of evidence have never been tested against each other. With our study, we wanted to address the aforementioned three aspects based on a large data basis from Germany. If many preservice teachers endorsed educational psychological misconceptions and these would not be reduced sufficiently through refutations with empirical evidence, this would have practical implications on teacher education in university courses (e.g. focus on these misconceptions, adaptation of the way we present empirical evidence).

Definition and Prevalence of Psychological Misconceptions

Psychological misconceptions can be defined as beliefs in wrong and popular assumptions that are contradictory to results from psychological research (Bensley and Lilienfeld 2015). Psychological misconceptions might arise from beliefs in psychological myths. For instance, believing in the myth that "It's better to express anger to others than to hold it in" (e.g. Lilienfeld, Lynn, Ruscio and Beyerstein 2010) leads to a misconception about this specific topic of interpersonal behavior. Other common psychological misconceptions concern "People use only 10% of their brain" (e.g. Higbee and Clay 1998) or "Playing Mozart's music to infants boosts their intelligence" (e.g. Lilienfeld et al. 2010). Psychological

misconceptions seem to be highly prevalent among both the general population and psychology students (e.g. Furnham and Hughes 2014; Hughes et al. 2015; Lilienfeld et al. 2010; McCutcheon 1991; McCutcheon, Furnham and Davis 1993; Taylor and Kowalski 2004; Vaughan 1977). Furnham and Hughes (2014) identified 37 myths in popular psychology believed by at least two thirds of their sample of both, the general population and psychology students. Psychology students endorsed significantly less psychological misconceptions than the general population, however, the effects were small. Regarding psychology students in more detail, about 28% of the presented common beliefs in psychology were not recognized to be wrong by at least half of the students from different introductory psychology classes in one study (Vaughan 1977) and, in another study, a sample from an introductory psychology class endorsed, at average, misconceptions about more than 60% of the presented topics (Taylor and Kowalski 2004). This research indicates that during the last decades, psychological misconceptions have been identified as a widespread issue and that having a background in psychology does not prevent from endorsing psychological misconceptions.

The seriousness of psychological misconceptions is pronounced when comparing their prevalence to the prevalence of misconceptions about general science topics. Often investigated common beliefs that are in opposition to a scientific consensus address climate change, vaccinations, evolution or HIV (e.g. Hamilton, Hartter and Saito 2015; Lewandowsky and Oberauer 2016). Concerning climate change, about 47% of a large sample from the United States did not totally agree that climate change is anthropogenic (Hamilton, Hartter, Lemcke-Stampone, Moore and Safford 2015) and in a British representative sample, about 18% considered natural processes mainly or entirely as causes of climate change (Poortinga, Spence, Whitmarsh, Capstick and Pidgeon 2011). Even though the claim that vaccinations cause autism has been proofed wrong many times (e.g. Taylor et al. 2002), about 25% of parents from a representative US sample still believed in this causal chain (Freed, Clark, Butchart, Singer and Davis 2010). Also, the purported connection between autism and vaccinations was named by

22% in Great Britain and 30% in Sweden to explain their concernedness against vaccinations (Stefanoff et al. 2010). Furthermore, between 7% (in Denmark) and about 45% (in Turkey) of an international sample believed that evolution is definitely false (Miller, Scott and Okamoto 2006). Also, ignoring the fact that HIV is a serious virus can be life-threatening because in this case, indispensable medication will not be provided. Even though these claims have been proven wrong many times, they are still believed by a significant percentage of people. However, this number is rather low compared to the number of people holding psychological misconceptions.

Prevalence of Educational Psychological Misconceptions Among (Preservice) Teachers

While previous research has focused on the general population and psychology students as well as general psychological misconceptions (see above), the group of (preservice) teachers and myths about topics from educational psychology have not received as much specific attention yet. But (preservice) teachers' misconceptions about topics from educational psychology are of special interest: Teachers will act as distributors of knowledge in their professional lives and should therefore be prevented from holding misconceptions. At least one of the myths about topics from educational psychology – the learning styles myth – has been investigated among (preservice) teachers in different countries. In studies in the United Kingdom, about 82% (Howard-Jones, Franey, Mashmoushi and Liao 2009) or even 93% (Dekker et al. 2012) of the participating teachers believed in it. In the Netherlands, the prevalence of this misconception among the interviewed teachers was 96% (Dekker et al. 2012). In Turkey, 97.6% of the preservice teacher sample agreed that individuals learn better when they receive information in their preferred learning style (Dündar and Gündüz 2016). In the French-speaking part of Switzerland, 87% of the (preservice) teacher sample believed that a pedagogical approach based on the distinction between visual and auditory learners would favor learning (Tardif, Doudin and Meylan 2015). Thus, the learning styles myth is not only one of

the most examined but probably also one of the most believed psychological myths in the educational context.

Even though these findings indicate a widespread belief in the learning styles myth among (preservice) teachers from various countries, findings from different countries cannot easily be transferred to another country. For instance, British and American students differed significantly in their endorsement of psychological misconceptions with British students endorsing significantly less misconceptions than American students (McCutcheon et al. 1993). Additionally, less is clear about preservice teachers' beliefs in other educational psychological myths apart from the learning styles myth (for a list of popular educational myths, see de Bruyckere, Kirschner and Hulshof 2015).

Consequences of Psychological Misconceptions Among (Preservice) Teachers

Psychological misconceptions are not only prevalent but also harmful. In general, prior knowledge affects future learning (see Ambrose and Lovett 2014), it can either ease or impede the growth of knowledge. Enhancement can occur through correct prior knowledge whereas impairment can occur through incorrect prior knowledge, like misconceptions (see Bransford, Brown and Cocking 1999; Thompson and Zamboanga 2004). Accordingly, Kuhle, Barber, and Bristol (2009) report a negative association between the number of psychological misconceptions held on the first day of an introductory psychology course and grades at the end of the course. Misconceptions can harm in other ways, too. For instance, a person with the "opposites attract"-misconception may not find the right partner due to inapt searching strategies based on this misconception (see Gardner and Brown 2013). Holding misconceptions can therefore be an impairment on the individual level through hindering learning or through leading decisions in a wrong direction.

Educational psychological misconceptions cannot only impede a single person but can even have a negative impact on the society level. As already mentioned, a group with particular

influence is the group of (preservice) teachers: If teachers hold psychological misconceptions about topics from the educational context, the reach of their negative influence can be tremendous because they will have an impact on many students throughout their careers. For example, if teachers believe that class size itself has a positive influence on students' learning outcomes, they might not seize the possible opportunities given by a smaller class (e.g. individualized instruction, increased participation of each student). There are several studies that show that teachers do not adapt their instructional practice to a significant extent to the number of children in their classes (e.g. Betts and Shkolnik 1999; Shapson, Wright, Eason and Fitzgerald 1980). However, research has shown that class size itself has no or if at all only a small effect on better learning outcomes, but teaching conditions like reciprocal teaching or providing feedback matter (Hattie 2009). Of course, if teachers believe that class size itself rather than the adaptation of their teaching methods matters, the risk of missing a chance to enhance students' learning outcomes increases.

There are numerous more situations in which teachers' misconceptions about topics from the educational context can lead to missed chances concerning learning facilitation or enhancement of learning outcomes. For example, if teachers deny the testing effect, believe in the learning styles myth or hold an opinion regarding multiple intelligences that is not in line with the current state of research, their teaching might differ from teachers who are knowledgeable about these topics. To sum up, teachers' psychological misconceptions concerning the educational context are a threat for educational practice because they can hinder learning as well as misdirect financial investment and time input (see Pasquinelli 2012).

Reduction of Psychological Misconceptions

In order to prevent the detrimental effects of teachers' misconceptions regarding educational psychological topics, not only the prevalence of these is of importance but also whether and how they can be reduced. Apparently, psychological misconceptions can be very

persistent (e.g. Gutman 1979; Vaughan 1977). Already former studies report that students in psychology introductory courses endorse nearly the same amount of psychological misconceptions before entering and after ending their course (e.g. Gardner and Dalsing 1986; Vaughan 1977). Further studies indicate that standard lectures are not sufficient to correct false beliefs but that it is necessary to use specific techniques (see Taylor and Kowalski 2014). Kowalski and Taylor (2009) used a specific technique in implementing refutational lectures in their psychology introductory course. These refutational lectures directly concentrated on common misconceptions as well as scientific evidence that contradicted the misconceptions. Standard lectures, on the other hand, addressed the scientific evidence but did not refer to the specific misconceptions. The procedure of the refutational lecture led to a greater change in disbelieving the popular but wrong claims compared to standard lectures or not covering the misconceptions' topics at all.

Refutations to counteract misconceptions can not only be applied in lectures but also in written texts. In a refutation-style text, the misconception is activated (e.g. through a statement or a question) and then directly refuted in combination with correct information and explanations (see Lassonde, Kolquist and Vergin 2017). In one study, undergraduates from psychology courses read different texts about multiple psychological misconceptions. One text, the refutation-style text, directly refuted the misconception and was combined with causal explanations that focused on scientific evidence. The other text, the non-refutation-style text, neither refuted the misconception directly nor was it combined with causal explanations. However, both versions of the texts offered the same correct outcome (i.e. disproving the misconception). As a result, students' beliefs in psychological misconceptions decreased more after reading a refutation-style text with causal explanations compared to beliefs in psychological misconceptions after reading a non-refutation-style text without causal explanations (Lassonde, Kendeou and O'Brien 2016). To sum up, changing psychological

misconceptions seems to be hard, but feasible through refutations implemented in lectures or written texts.

The Role of Anecdotal Evidence for (Preservice) Teachers

Causal explanations (see above) can be based on various sources (e.g. findings from research or experience-based explanations). According to Hargreaves (2000), preservice teachers do not consider research as helpful for practical problems and teachers mainly trust in their own experiences. More precisely, there is growing evidence that (preservice) teachers do not primarily rely on findings from educational research for their decisions but rather concentrate on experience-based knowledge (e.g. Allen 2009; Bråten and Ferguson 2015; Gitlin, Barlow, Burbank, Kauchak and Stevens 1999; Hargreaves 2000; Ingram, Seashore Louis and Schroeder 2004; Parr and Timperley 2008; Williams and Coles 2007). Relying on informal information instead of sound scientific information, however, might not only result in the negative consequences mentioned above but also conflicts with current calls for evidence-based practice (see Bauer and Prenzel 2012; Slavin 2002). For example, in one study, interviewed preservice teachers indicated that research was less important than experience and that they would use teachers as resources in order to make decisions (Gitlin et al. 1999). Additionally, preservice teachers of another study mentioned that (pedagogical) theory from teacher education was rather useless for classroom practice (Sjølie 2014). Also, interviewed teachers from the UK named discussions with teaching colleagues as their most used source when looking for research information (Williams and Coles 2007). Bråten and Ferguson (2015) reported that preservice teachers showed a higher preference for experiential and practically-derived sources of knowledge compared to theory-based sources concerning instruction and student learning. Moreover, these preservice teachers showed a strong motivation to learn from practice. Additionally, at least German teachers do not seem to use scientific findings from educational science to plan their classes (Hetmanek et al. 2015). Taking together, literature

indicates that anecdotal evidence plays a vital role in (preservice) teachers' professional lives whereas empirical evidence and research seem to be less important.

The Current Study

With our study, we wanted to address the prevalence and possible reduction of educational psychological misconceptions among preservice teachers in Germany. Previous research has focused on psychological misconceptions among the general public and psychology students in particular. However, the negative impact of teachers who endorse educational psychological misconceptions has been neglected and some studies have indicated some acceptance problems of empirical evidence among (preservice) teachers. If (preservice) teachers do not believe in empirical evidence, this might impede the requested concept of evidence-based education (e.g. Slavin 2002). To ensure quality of teaching and learning, it is important that teachers, if they hold misconceptions about topics from educational psychology, will shift their opinion based on empirical evidence. Corrective action should be applied at an early stage in education, hence, already with preservice teachers.

Psychology plays an important role in teacher education (see Anderson et al. 1995; for Germany see Author et al. 2018), especially educational psychological knowledge is of importance for (preservice) teachers (e.g. Patrick, Anderman, Bruening and Duffin 2011; for Germany see KMK 2004). However, to the best of our knowledge, whether preservice teachers in Germany endorse different educational psychological misconceptions has not been investigated yet. Due to the general high prevalence of psychological misconceptions and the high prevalence of at least one misconception from the educational psychological context (learning styles) among preservice teachers in different countries, we expect the prevalence of the investigated educational psychological misconceptions to be high among preservice teachers in Germany. The prevalence is expected to be both, high in absolute terms as well as higher than the prevalence of misconceptions about general science topics. Further, we wanted

to know whether it is possible to change preservice teachers' wrong opinions about educational psychological topics through short refutation-style texts about the current state of research. According to literature, these refutation-style texts have been proven a suitable tool to change students' misconceptions about psychological topics (e.g. Lassonde et al. 2016) and should therefore also work for preservice teachers with misconceptions about educational psychological topics. Hence, we expect shifts of opinion (i.e. from (strongly) endorsing a misconception before reading the text to (rather) not endorsing a misconception after reading the text) for every topic from educational psychology. Additionally, literature suggests that (preservice) teachers believe experience-based information to be more important to them than evidence-based information (e.g. Bråten and Ferguson 2015). However, to the best of our knowledge, this is the first study to directly test whether anecdotal or empirical evidence is more believed in. According to the literature (e.g. Bråten and Ferguson 2015; Gitlin et al. 1999; Hargreaves 2000) we expect preservice teachers to shift their opinion more after reading the anecdotal version of the refutation-style text compared to the empirical version of the refutation-style text.

Thus, our study addresses the following three hypotheses:

1. Misconceptions about topics from educational psychology are highly prevalent among preservice teachers, both in absolute terms and compared to the prevalence of misconceptions about general science topics.

2. Preservice teachers with misconceptions about topics from educational psychology will shift their opinion after reading a refutation-style text about the current state of research.

3. Preservice teachers with misconceptions about topics from educational psychology will indicate a more pronounced shift of their opinion after reading an anecdotal version of the refutation-style text compared to an empirical version of the refutation-style text.

Method

Data Collection

For this study, an online survey via the online questionnaire tool SoSci-Survey was conducted. The presented study was imbedded in an investigation that also assessed students' perception of scientific findings from different scientific (sub-)disciplines. Data collection was carried out between November 2017 and January 2018. Participants were recruited by asking them to take part in a study about the perception of scientific findings from different disciplines. We distributed the link to the online survey via social media platforms for preservice teachers in Germany, personal contact, mailing lists for preservice teachers and lectures imbedded in preservice teachers' syllabus at different universities in Germany. Participation in this study was not associated with any specific university course and participants did not receive any course credit. Instead, we encouraged preservice teachers to support psychological research and offered them the chance to take part in a lottery of 20 x 20€. Participants were free to choose the location and time for doing the online survey by using their own technical devices. Enrollment for teacher education at a German institution was the only requirement of participating in this study. Due to the disengagement of the study from any further restrictions, a diverse sample of preservice teachers in Germany (e.g. regarding age, location, study program) was recruited (see below). Participation was voluntary and took approximately 15 minutes. Participants were informed about the anonymous data collection, provided informed consent and could abandon the survey at any time. Because of recruitment via snowball system, it is not possible to determine a return rate, however, completion rate of all started surveys was 77.8% and due to the settings of the survey, there were no missing data.

Participants

Three participants with their study location outside Germany were removed from the initial sample. Thus, the total sample of this study consisted of N = 937 preservice teachers

(77.5% female). This gender distribution fairly well represents the typical gender distribution of preservice teachers in Germany (DESTATIS, 2019). The mean age of the sample was *M* = 22.08 years (*SD* = 3.35) and 56% had attended one or more than one course of educational psychology during their study period. Participants were studying in 14 of 16 German federal states and at average, they were in their fourth semester (*M* = 4.11; *SD* = 3.27). The preservice teachers of this sample studied to become different kinds of teachers (i.e. 53% high school teacher, 17.1% elementary school teacher, 11.8% comprehensive school teacher, 9.1% special school teacher, 5.1% both a high school and a comprehensive school teacher, 3.7% vocational school teacher). In Germany, preservice teachers normally study at least two school subjects. Taking together the first, the second, and the third subjects, German was the most studied subject, with 389 preservice teachers studying it, followed by mathematics (293) and English (218).

Procedure

To address the first hypothesis regarding the prevalence of educational psychological misconceptions, we selected four specific topics from educational psychology. To our knowledge, there is no existing questionnaire covering specific *educational psychological* topics. While Dekker and colleagues (2012) investigated *neuromyths in education*, we were interested in a broader range of educational psychological topics. Thus, we chose topics that are common in preservice teacher education in Germany and that are of extreme relevance to (preservice) teachers, because correct knowledge about these topics could be directly transferred to evidence-based actions by (preservice) teachers themselves. Of our topics, three claims refer to the importance of learning styles, class sizes, and the testing effect for better learning outcomes. Thus, we included one topic (i.e. learning styles) that was also investigated by Dekker and colleagues (2012) as one of the most prevalent neuromyths in education. The first two claims have been contradicted by empirical evidence while the latter has been strongly

supported by empirical evidence. As a fourth topic, we chose multiple intelligences, which have been classified as "a kind of philosophy rather than a proven theory […] that has the potential to become a myth, if taken too seriously" (de Bruyckere et al. 2015; p. 68). De Bruyckere and colleagues (2015) also speculate on the origin of these educational psychological misconceptions: They might either contradict gut feelings (class size) or appear intuitively appealing (learning styles). Further, several educational psychological misconceptions might be based on the desire to believe that the statement is true. Further, we selected four general science topics that have been investigated in previous studies (i.e. climate change, evolution, vaccinations, HIV). Participants indicated their agreement to the general science topics first and to the educational psychology topics afterwards to prevent possible transfer effects of the educational psychological refutation-style texts on the general scientific topics.

To address the second and the third hypotheses regarding the reduction of educational psychological misconceptions after reading (different) refutation-style texts, participants were randomly assigned to either an empirical or an anecdotal version of the texts. In order to prevent participants from an excessive demand, only misconceptions about the aforementioned four educational psychological topics were investigated. After indicating their opinion concerning the first topic, participants read a short refutation-style text with causal explanations about the current state of research concerning this topic. This text was either presented in the form of a summary of empirical studies (i.e. empirical version) or in the form of a personal report by companioned teachers (i.e. anecdotal version). Both versions refuted the popular misconception directly and were followed by short causal explanations, either backed up with empirical studies or personal experiences. Afterwards, the aforementioned statement was repeated and participants were asked how much they agreed with it *now*. The same procedure followed for the other three topics.

Materials

Topics from educational psychology. To measure the prevalence of educational psychological misconceptions among preservice teachers, their opinion concerning four specific topics from educational psychology (i.e. learning styles, multiple intelligences, testing effect, and class size) was assessed using one item for each topic (e.g. "*How much do you agree with the thesis that there are different learning styles (e.g. auditory, visual or kinesthetic) that enable more effective learning?*"; see Appendix A for all items). Participants indicated their agreement to the statements on a five-point Likert-Scale (1 = *"I do not agree at all"*; 5 = *"I agree very much"*) for each item.

General science topics. To measure the prevalence of general science misconceptions among preservice teachers, their opinion concerning four specific topics from general science (i.e. climate change, evolution, vaccinations, and HIV) was assessed using one item for each topic (e.g. "*Climate change is also caused by humans.*"; see Appendix B for all items). Participants indicated their agreement to the statements on a five-point Likert-Scale (1 = *"I do not agree at all"*; 5 = *"I agree very much"*) for each item.

Empirical version. One version of the refutation-style texts presented the current state of research in an evidence-based format (i.e. a summary of empirical studies). For learning styles, multiple intelligences and class size, the text started with "*The current state of research in educational psychology indicates that [the statement is **not** true]*" and for the testing effect, the text started with "*The current state of research in educational psychology indicates that [the statement is **indeed** true]*". After this first sentence, each text referred to several studies that reported evidence on the (in)correctness of the claims. Further, the text included explanations on why the specific misconceptions might have arisen.

Anecdotal version. The other version of the refutation-style texts presented the current state of research in an experience-based format (i.e. a personal report by companioned teachers). For learning styles, multiple intelligences and class size, the text started with "*Companioned*

*teachers tell you that they have experienced that [the statement is **not** true]*" and for the testing effect, the text started with "*Companioned teachers tell you that they have experienced that [the statement is **indeed** true]*". Further, the texts included examples from these teachers' many years of experience that explain why the statement cannot be true (i.e. for learning styles, multiple intelligences, and class size) or must be true (i.e. for the testing effect).

Statistical analyses

The program IBM SPSS Statistics (version 24) was used for all statistical analyses. A dependent *t*-test for paired samples was used to examine whether preservice teachers' misconceptions about topics from educational psychology and their misconceptions about general science topics differed. Analyses of variance (ANOVAs) with repeated measures for each topic of educational psychology were used to investigate whether participants changed their opinion after reading a short text about the current state of research and whether the change of their opinion differed between the two groups (empirical version vs. anecdotal version).

Results

Below, the prevalence of educational psychological misconceptions is presented – first in absolute terms and then compared to misconceptions about general science topics. The frequencies of each response category (i.e. level of agreement) of every misconception (educational psychological misconceptions and general science misconceptions) are depicted in detail in Table 1. Afterwards, results about preservice teachers' change of their wrong knowledge about topics from educational psychology – in general and depending on the version – are displayed. Table 2 depicts descriptive statistics of the ANOVAs.

Prevalence of Misconceptions About Topics from Educational Psychology

Descriptive statistics concerning the four different topics from educational psychology were analyzed to investigate whether and to what extent misconceptions about these topics are

prevalent among preservice teachers in Germany. In this study, holding a misconception was defined as (*rather* or *very much*) agreeing (i.e. agreement ≥ 4) to a claim that is not in accordance with the current state of research. For learning styles, 95% of the participants indicated an opinion contrary to the current state of research, for multiple intelligences it was 88.2%. Asked about the testing effect, 7.9% indicated an opinion contrary to the current state of research, for class size it was 85.6%. These numbers of prevalence indicate that misconceptions about most of the investigated topics from educational psychology are endorsed by the vast majority of preservice teachers in Germany.

[Table 1 near here]

To investigate whether preservice teachers' opinion concerning topics from educational psychology and their opinion concerning general science topics differ, a dependent *t*-test for paired samples was conducted. All items were recoded so that low values indicate an opinion in accordance with the current scientific level of knowledge. There was a significant difference between the topics from educational psychology (M = 3.83; SD = 0.47) and general science topics (M = 1.81; SD = 0.54); $t(936) = 85.171$, $p < .001$, $d = 4.00$. This result suggests that preservice teachers' opinions concerning topics from educational psychology are less in accordance with the current scientific level of knowledge than their opinion concerning general science topics.

Reduction of Misconceptions About Topics from Educational Psychology – General and Depending on the Kind of Evidence

To analyze whether preservice teachers' misconceptions about topics from educational psychology can generally be changed as well as whether the change depends on how they are confronted with the current state of research, a 2 (empirical version vs. anecdotal version) x 2 (before reading the refutation-style text vs. after reading the refutation-style text) ANOVA with repeated measures was conducted for each of the four topics. For every topic except the testing

effect, only participants indicating a misconception (i.e. agreement ≥ 4) were included in this analysis. Because the prevalence of the misconception concerning the testing effect was low, all participants indicating an agreement ≥ 3 (i.e. indicating an opinion not in accordance with the current state of research) were included for this topic. In total, 890 participants were included in the analysis concerning learning styles and 825 participants were included in the analysis concerning multiple intelligences. To analyze the testing effect, 240 participants were included and to analyze class size, 802 participants were included.

[Table 2 near here]

For learning styles, the 2 x 2 ANOVA with repeated measures showed a statistically significant main effect of version ($F(1,888) = 82.626$, $p < .001$, $d = 0.61$) and of time ($F(1,888) = 469.534$, $p < .001$, $d = 1.45$). Additionally, a statistically significant interaction effect was found, ($F(1,888) = 110.556$, $p < .001$, $d = 0.71$), indicating a more pronounced change of opinion after reading the empirical version of the text. The analogous ANOVA for multiple intelligences revealed a statistically significant main effect of version ($F(1,823) = 89.709$, $p < .001$, $d = 0.66$) and of time ($F(1,823) = 333.619$, $p < .001$, $d = 1.27$). Additionally, a statistically significant interaction effect was found, ($F(1,823) = 89.600$, $p < .001$, $d = 0.66$), indicating a more pronounced change of opinion after reading the empirical version of the text. For the testing effect, results showed a statistically significant main effect of time ($F(1,238) = 226.237$, $p < .001$, $d = 1.95$) and a statistically significant interaction effect ($F(1,238) = 36.177$, $p < .001$, $d = 0.78$), indicating that participants reading the empirical version changed their opinion to a more pronounced extent even though they started with stronger misconceptions. For class size, we found a statistically significant main effect of version ($F(1,800) = 4.382$, $p < .05$, $d = 0.14$) and of time ($F(1,800) = 347.921$, $p < .001$, $d = 1.32$). Additionally, a statistically significant interaction effect was found, ($F(1,800) = 26.555$, $p < .001$, $d = 0.36$), indicating that participants

reading the empirical version changed their opinion more even though they started with stronger misconceptions.

In sum, these results suggest that preservice teachers changed their wrong opinions about educational psychological topics more when confronted with the current state of research presented in an empirical version compared to an anecdotal version of a refutation-style text. A rigorous shift of opinion was only assumed when participants indicated an agreement of ≥ 4 (i.e. *rather* or *very much*) before reading the text and an agreement of ≤ 2 (i.e. *rather not* or *not at all*) after reading each text about the current state of research. The percentage of participants who rigorously shifted their opinion was rather small in absolute terms, see Table 3.

[Table 3 near here]

Discussion

One aim of this study was to gain a first insight into the prevalence of misconceptions about different topics from educational psychology among preservice teachers in Germany. In line with our first hypothesis, the prevalence of educational psychological misconceptions among preservice teachers was very high: For each topic (except the testing effect), more than 80% of the participants indicated an opinion contrary to the current state of research. The prevalence of the learning styles myth was particularly high, namely 95%, which is in accordance with previous literature that reports the prevalence of this myth in different countries to range from 82% to 97.6% (e.g. Dekker et al. 2012; Dündar and Gündüz 2016; Howard-Jones et al. 2009; Tardif et al. 2015). Additionally, the severity of educational psychological misconceptions' dissemination was emphasized through a comparison to the dissemination of general science misconceptions. In detail, preservice teachers' knowledge about general science topics was in strong accordance with the recent state of knowledge whereas their knowledge about central educational psychological topics was not. The findings

of this study expand previous literature in transferring the results from the learning styles myth to other educational psychological topics and to another country.

Another aim of this study was to investigate whether refutation-style texts about the current state of research lead to a change of wrong beliefs in educational topics among preservice teachers. In line with our second hypothesis, reading refutation-style texts resulted in a reduction of misconceptions about each topic. This finding extends the previous literature on psychology students (e.g. Kowalski and Taylor 2009; Lassonde et al. 2016) to preservice teachers. Even though the refutation-style texts worked overall, only a minority of participants rigorously shifted their opinion. This finding indicates that confronting preservice teachers with refutational information – which lectures at university often do – may be insufficient to really change students' opinions.

Contrary to our third hypothesis, participants reading the empirical version of the refutation-style text indicated a more pronounced change of their opinion compared to participants reading the anecdotal version of the text. In addition, more people in the empirical version group compared to the anecdotal version group showed a rigorous shift of opinion. We had expected the anecdotal version to be more powerful because previous research has indicated that (preservice) teachers do not primarily rely on findings from educational research but rather name experience (e.g. Bråten and Ferguson 2015; Gitlin et al. 1999) and other teachers (e.g. Gitlin et al. 1999; Williams and Coles 2007) as important sources for their decisions. However, the assumption that (preservice) teachers concentrate on experience-based knowledge or intuition instead of evidence-based research was often based on research which either did not use any data (e.g. Hargreaves 2000; Labaree 2003) or only small samples (e.g. Allen 2009). In our data-based study with a large and heterogeneous sample, preservice teachers changed their opinion more in the empirical version group than students in the anecdotal version group. Thus, the preservice teachers showed higher trust in empirical than anecdotal explanations for the

formation of their opinion. This result indicates that preservice teachers do not devalue empirical findings but use them in a positive way to a certain extent. Nevertheless, the majority of participants reading the empirical refutation-style text did not rigorously shift their opinion which indicates that these preservice teachers could not be convinced by empirical evidence. The findings of this study are therefore in line with previous literature but allow a more differentiated view on the power of empirical evidence to reduce misconceptions among preservice teachers.

Limitations

In this study, the prevalence of educational psychological misconceptions was measured for only four topics. These topics were chosen because of their high importance for (preservice) teachers and their professional lives and can be viewed as a first indicator of prevalence. Also, only very few participants, namely 7.9%, denied the testing effect. This is a pleasant finding because it indicates that preservice teachers do not only hold misconceptions about topics from educational psychology. However, there have been no claims that testing was not useful for learning. That is, something like the opposite of the testing effect has not been classified as an educational psychological misconception. Hence, the testing effect might not have been an optimal topic for the purpose of our study. As a first investigation, our study only sheds light on the status quo of prevalence and does not offer an insight into causes and sources of these misconceptions. Another limitation of this study is the lack of a follow-up investigation. Based on our study, we cannot say whether and how long the changes of opinions last. Further, because we only collected self-reports and no behavioral data, we do not know whether the successful refutation of a misconception leads to behavioral implementations in the classroom that are in accordance with the current state of research. Additionally, preservice teachers' voluntary participation in our study could be a sign for their high interest in the topic. It would deepen

our knowledge to repeat our study with preservice teachers who show low interest in the topic. This might result in even more alarming findings.

Practical Implications and Future Research

The investigated educational psychological misconceptions about learning styles, the existence of multiple intelligences and the influence of class size on students' learning appear very hardened among German preservice teachers. As already mentioned, only few preservice teachers rigorously shifted their opinion after reading a refutation-style text. As confronting students with empirical evidence is an approach often implemented in university lectures, we can assume that preservice teachers fail to evolve their full potential in exams when they endorse misconceptions about covered topics. In addition, this could mean that preservice teachers leave their lectures still endorsing misconceptions. Even more alarming, they might also enter their professional lives with these misconceptions, which can have severe implications, for example, hinder their students' learning and result in a waste of time and money (see Pasquinelli 2012). As a first step, it is important for university instructors to be alert about specific and possibly hardened misconceptions among their students in order to target them. Further, future research needs to concentrate on diverse interventions to target preservice teachers' misconceptions in other and more efficient ways. Hence, it is worthwhile to conduct a longitudinal study to investigate whether interventions only have short-term or also long-term effects, lasting for students' duration of study and even their practical work. In this regard, investigating behavioral outcomes affected by educational psychological misconception endorsement would add new knowledge about consequences of these misconceptions among teachers. Future work should also extend investigations to other topics from educational psychology to draw an accurate and representative picture of the prevalence of different educational psychological misconceptions among preservice teachers. It is also of high interest where these misconceptions come from. Taylor and Kowalski (2004) report that psychology

students in their study mostly did not remember the sources of their misconceptions. In order to counteract misconceptions efficiently, it is important to know whether preservice teachers derive their misconceptions about educational psychology from personal experiences, the media or maybe even previous classes. Different origins of misconceptions might ask for different kinds of rebuttal: If people believe their knowledge is based on scientific evidence – but in fact this evidence is outdated or not scientific at all – it might be helpful to present them with the latest rigorous scientific evidence. On the other hand, if people base their knowledge on personal experiences, it might be helpful to make them aware of possible cognitive biases that we all fall victim to.

Conclusion

This study illustrates that preservice teachers from Germany hold misconceptions about topics from educational psychology. University instructors need to be informed about these misconceptions and should target them in an efficient way during their lectures. It is important to prevent teachers from entering their professional lives with misconceptions about topics from educational psychology because this could otherwise lead to serious consequences for society. Our findings are in line with previous literature concerning the persistence of psychological misconceptions. Although some preservice teachers rigorously shifted their opinion after reading a refutation-style text with empirical evidence, the vast majority did not. Future research in this area should investigate further educational psychological misconceptions, identify different reasons and sources for the endorsement of misconceptions and concentrate on efficient ways to counteract misconceptions among preservice teachers.

References

Author et al (2018). Blinded for anonymous review.

Allen, J. M. (2009). Valuing practice over theory: How beginning teachers re-orient their practice in the transition from the university to the workplace. *Teaching and Teacher Education, 25*, 647–654. doi:10.1016/j.tate.2008.11.011

Ambrose, S. A., & Lovett, M. C. (2014). Prior knowledge is more than content: Skills and beliefs also impact learning. In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum* (pp. 7–20). Washington, DC: American Psychological Association (Division 2).

Anderson, L. M., Blumenfeld, P., Pintrich, P. R., Clark, C. M., Marx, R. W., & Peterson, P. (1995). Educational psychology for teachers: Reforming our courses, rethinking our roles. *Educational Psychologist, 30*, 143–157. doi:10.1207/s15326985ep3003_5

Bauer, J., & Prenzel, M. (2012). Science education. European teacher training reforms. *Science, 336*, 1642–1643. doi:10.1126/science.1218387

Bensley, D. A., & Lilienfeld, S. O. (2015). What is a psychological misconception? Moving toward an empirical answer. *Teaching of Psychology, 42*, 282–292. doi:0.1177/0098628315603059

Betts, J. R., & Shkolnik, J. L. (1999). The behavioral effects of variations in class size: The case of math teachers. *Educational Evaluation and Policy Analysis, 21*(2), 193–213. doi:10.3102/01623737021002193

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Bråten, I., & Ferguson, L. E. (2015). Beliefs about sources of knowledge predict motivation for learning in teacher education. *Teaching and Teacher Education, 50*, 13–23. doi:10.1016/j.tate.2015.04.003

de Bruyckere, P., Kirschner, P. A., & Hulshof, C. D. (2015). *Urban myths about learning and education*. London: Elsevier.

Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology, 3*(429), 1–8. doi:10.3389/fpsyg.2012.00429

DESTATIS (2019). Bildung und Kultur: Studierende an Hochschulen (Vorbericht) [Education and culture: Students in higher education (preliminary report)]. Retrieved from https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bildung-Forschung-Kultur/Hochschulen/Publikationen/Downloads-Hochschulen/studierende-hochschulen-vorb-2110410198004.html

Dündar, S., & Gündüz, N. (2016). Misconceptions regarding the brain: The neuromyths of preservice teachers. *Mind, Brain, and Education, 10*, 212–232. doi:10.1111/mbe.12119

Freed, G. L., Clark, S. J., Butchart, A. T., Singer, D. C., & Davis, M. M. (2010). Parental vaccine safety concerns in 2009. *Pediatrics, 125*, 654–659. doi:10.1542/peds.2009-1962

Furnham, A., & Hughes, D. J. (2014). Myths and misconceptions in popular psychology: Comparing psychology students and the general public. *Teaching of Psychology, 41*, 256–261. doi:10.1177/0098628314537984

Gardner, R. M., & Brown, D. L. (2013). A test of contemporary misconceptions in psychology. *Learning and Individual Differences, 24*, 211–215. doi:10.1016/j.lindif.2012.12.008

Gardner, R. M., & Dalsing, S. (1986). Misconceptions about psychology among college students. *Teaching of Psychology, 13*, 32–34. doi:10.1207/s15328023top1301_9

Gitlin, A., Barlow, L., Burbank, M. D., Kauchak, D., & Stevens, T. (1999). Pre-service teachers' thinking on research: Implications for inquiry oriented teacher education. *Teaching and Teacher Education, 15*, 753–769. doi:10.1016/S0742-051X(99)00015-3

Gutman, A. (1979). Misconceptions of psychology and performance in the introductory course. *Teaching of Psychology, 6*, 159–161. doi:10.1207/s15328023top0603_9

Hamilton, L. C., Hartter, J., Lemcke-Stampone, M., Moore, D. W., & Safford, T. G. (2015). Tracking public beliefs about anthropogenic climate change. *PLoS One, 10*(9), e0138208. doi:10.1371/journal.pone.0138208

Hamilton, L. C., Hartter, J., & Saito, K. (2015). Trust in scientists on climate change and vaccines. *SAGE Open, 5*(3), 1–13. doi:10.1177/2158244015602752

Hargreaves, D. H. (2000). Teaching as a research-based profession: Possibilities and prospects. In B. Moon, J. Butcher, & E. Bird (Eds.), *Leading professional development in education* (pp. 200–210). London: RoutledgeFalmer.

Hattie, J. A. C. (2009). *Visible learning: A synthesis of over 800 meta-analyses on achievement*. London: Routledge.

Hetmanek, A., Wecker, C., Kiesewetter, J., Trempler, K., Fischer, M. R., Gräsel, C., & Fischer, F. (2015). Wozu nutzen Lehrkräfte welche Ressourcen? Eine Interviewstudie zur Schnittstelle zwischen bildungswissenschaftlicher Forschung und professionellem Handeln im Bildungsbereich [For what do teachers use which kind of resources? An interview study on the interface between research and professional practice in education]. *Unterrichtswissenschaft, 43*, 193–208.

Higbee, K. L., & Clay, S. L. (1998). College students' beliefs in the ten-percent myth. *Journal of Psychology: Interdisciplinary and Applied, 132*, 469–476.

Howard-Jones, P., Franey, L., Mashmoushi, R., & Liao, Y.-C. (2009). *The neuroscience literacy of trainee teachers*. Paper presented at British Educational Research Association Annual Conference, Manchester.

Hughes, S., Lyddy, F., Kaplan, R., Nichols, A. L., Miller, H., Saad, C. G., ... Lynch, A.-J. (2015). Highly prevalent but not always persistent: Undergraduate and graduate student's misconceptions about psychology. *Teaching of Psychology, 42*, 34–42. doi:10.1177/0098628314562677

Ingram, D., Seashore Louis, K., & Schroeder, R. G. (2004). Accountability policies and teacher decision making: Barriers to the use of data to improve practice. *Teachers College Record, 106*, 1258–1287.

KMK [Kultusministerkonferenz] (2004). *Standards für die Lehrerbildung: Bildungswissenschaften. Beschluss der Kultusministerkonferenz.* [*Standards for teacher education. Decision of the Conference of the Ministers of Education and Cultural Affairs.*] Bonn: KMK.

Kowalski, P., & Taylor, A. (2009). The effect of refuting misconceptions in the introductory psychology class. *Teaching of Psychology, 36*, 153–159. doi:10.1080/00986280902959986

Kuhle, B. X., Barber, J. M., & Bristol, A. S. (2009). Predicting students' performance in introductory psychology from their psychology misconceptions. *Journal of Instructional Psychology, 36*, 119–124.

Labaree, D. F. (2003). The peculiar problems of preparing educational researchers. *Educational Researcher, 32*, 13–22. doi:10.3102/0013189X032004013

Lassonde, K. A., Kendeou, P., & O'Brien, E. J. (2016). Refutation texts: Overcoming psychology misconceptions that are resistant to change. *Scholarship of Teaching and Learning in Psychology, 2*, 62–74. doi:10.1037/stl0000054

Lassonde, K. A., Kolquist, M., & Vergin, M. (2017). Revising psychology misconceptions by integrating a refutation-style text framework into poster presentations. *Teaching of Psychology, 44*, 255–262. doi:10.1177/0098628317712754

Lewandowsky, S., & Oberauer, K. (2016). Motivated rejection of science. *Current Directions in Psychological Science, 25*, 217–222. doi:10.1177/0963721416654436

Lilienfeld, S., Lynn, S., Ruscio, J., & Beyerstein, B. (2010). *50 great myths of popular psychology*. Oxford, England: Wiley-Blackwell.

McCutcheon, L. E. (1991). A new test of misconceptions about psychology. *Psychological Reports, 68*, 647–653.

McCutcheon, L. E., Furnham, A., & Davis, G. (1993). A cross-national comparison of students' misconceptions about psychology. *Psychological Reports, 72*(1), 243–247.

Miller, J. D., Scott, E.C., & Okamoto, S. (2006) Public acceptance of evolution. *Science, 313*, 765–766. doi:10.1126/science.1126746

Parr, J. M., & Timperley, H. S. (2008). Teachers, schools and using evidence: Considerations of preparedness. *Assessment in Education: Principles, Policy & Practice, 15*, 57–71. doi:10.1080/09695940701876151

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*, 89–96. doi:10.1111/j.1751-228X.2012.01141.x

Patrick, H., Anderman, L. H., Bruening, P. S., & Duffin, L. C. (2011). The role of educational psychology in teacher education: Three challenges for educational psychologists. *Educational Psychologist, 46*(2), 71–83. doi:10.1080/00461520.2011.538648

Poortinga, W., Spence, A., Whitmarsh, L., Capstick, S., & Pidgeon, N. F. (2011). Uncertain climate: An investigation into public scepticism about anthropogenic climate change. *Global Environmental Change, 21*, 1015–1024. doi:10.1016/j.gloenvcha.2011.03.001

Shapson, S. M., Wright, E. N., Eason, G., & Fitzgerald, J. (1980). An experimental study of the effects of class size. *American Educational Research Journal, 17*(2), 141–152. doi:10.3102/00028312017002141

Sjølie, E. (2014). The role of theory in teacher education: Reconsidered from a student teacher perspective. *Journal of Curriculum Studies, 46*, 729–750. doi:10.1080/00220272.2013.871754

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*(7), 15–21. doi:10.3102/0013189X031007015

Stefanoff, P., Mamelund, S.-E., Robinson, M., Netterlid, E., Tuells, J., Bergsaker, M. A. R., ... The VACSATC working group on standardization of attitudinal studies in Europe. (2010). Tracking parental attitudes on vaccination across European countries: The vaccine safety, attitudes, training and communication project (VACSATC). *Vaccine, 28*(35), 5731–5737. doi:10.1016/j.vaccine.2010.06.009

Tardif, E., Doudin, P.-A., & Meylan, N. (2015). Neuromyths among teachers and teacher students. *Mind, Brain, and Education, 9*, 50–59. doi:10.1111/mbe.12070

Taylor, A. K., & Kowalski, P. (2004). Naive psychological science: The prevalence, strength, and sources of misconceptions. *Psychological Record, 54*(1), 15–25.

Taylor, A. K., & Kowalski, P. (2014). Student misconceptions: Where do they come from and what can we do? In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum* (pp. 259–273). Washington, DC: American Psychological Association (Division 2).

Taylor, B., Miller, E., Lingam, R., Andrews, N., Simmons, A., & Stowe, J. (2002). Measles, mumps, and rubella vaccination and bowel problems or developmental regression in children with autism: Population study. *British Medical Journal, 324*, 393–396. doi:10.1136/bmj.324.7334.393

Thompson, R. A., & Zamboanga, B. L. (2004). Academic aptitude and prior knowledge as predictors of student achievement in introduction to psychology. *Journal of Educational Psychology, 96*, 778–784. doi:10.1037/0022-0663.96.4.778

Vaughan, E. D. (1977). Misconceptions about psychology among introductory psychology students. *Teaching of Psychology, 4*, 138–141. doi:10.1207/s15328023top0403_9

Williams, D., & Coles, L. (2007). Evidence-based practice in teaching: An information perspective. *Journal of Documentation, 63*, 812–835. doi:10.1108/00220410710836376

Appendix A: English Translation of the Items About Educational Psychological Topics

Learning styles: “How much do you agree with the thesis that there are different learning styles (e.g., auditory, visual or kinesthetic) that enable more effective learning?” (false)

Multiple intelligences: “How much do you agree with the thesis that multiple intelligences (e.g., verbal-linguistic, logical-mathematical, visual-spatial intelligences) exist?” (false)

Testing effect: “How much do you agree with the thesis that repeated (self)-testing (e.g., with the aid of flashcards or quizzes) leads to better long-term learning than repeated reading of the material?” (true)

Class size: “How much do you agree with the thesis that the number of pupils in a class (i.e., class size) influences pupils learning?” (false)

Appendix B: English Translation of the Items About General Science Topics

“How much do you agree with the following statements?”

Climate change: “Climate change is also caused by humans.” (true)

Evolution: “Humans and apes do not share common ancestors.” (false)

Vaccinations: “Autism is a developmental disorder that can be caused through vaccinations.” (false)

HIV: “HIV leads to AIDS if it is not treated.” (true)

Table 1

	Not at all	Rather not	Neither / nor	Rather	Very much	*N*	*M*	*SD*
Educational Psychological Topics								
Learning styles	5 (0.5)	17 (1.8)	24 (2.6)	193 (20.6)	697 (74.4)	936	4.67	0.67
Multiple intelligences	7 (0.7)	37 (3.9)	66 (7.0)	319 (34.0)	508 (54.2)	937	4.37	0.84
Testing effect	352 (37.6)	345 (36.8)	166 (17.7)	59 (6.3)	15 (1.6)	937	1.98	0.97
Class size	16 (1.7)	58 (6.2)	60 (6.4)	294 (31.4)	508 (54.2)	936	4.30	0.96
General Science Topics								
Climate change	678 (72.4)	238 (25.4)	9 (1.0)	9 (1.0)	2 (0.2)	936	1.31	0.56
Evolution	624 (66.6)	174 (18.6)	42 (4.5)	39 (4.2)	57 (6.1)	936	1.64	1.14
Vaccinations	443 (47.3)	263 (28.1)	146 (15.6)	68 (7.3)	15 (1.6)	935	1.88	1.03
HIV	277 (29.6)	312 (33.3)	149 (15.9)	84 (9.0)	115 (12.3)	937	2.41	1.32

Note. For each topic, high values for “rather” and “very much” indicate a misconception.

Table 2

Descriptive Statistics of the ANOVAs With Repeated Measures for the Topics From Educational Psychology

	Empirical Version		Anecdotal Version	
	M	*SD*	*M*	*SD*
Learning styles pre	4.77	0.42	4.79	0.41
Learning styles post	3.67	1.28	4.41	1.12
Multiple intelligences pre	4.54	0.50	4.68	0.47
Multiple intelligences post	3.71	1.19	4.42	0.74
Testing effect pre	3.46	0.67	3.25	0.46
Testing effect post	2.27	0.89	2.73	0.87
Class size pre	4.47	0.47	4.60	0.49
Class size post	3.93	1.09	4.18	0.83

Note. $N_{\text{learning styles}} = 890$, $N_{\text{multiple intelligences}} = 825$, $N_{\text{testing effect}} = 240$, $N_{\text{class size}} = 802$.

Table 3

Percentage of Participants Indicating a Rigorous Shift of Opinion After Reading a Refutation-style Text About the Current State of Research

	Empirical Version	Anecdotal Version	Overall
Learning styles	21.6	3.0	12.0
Multiple intelligences	17.3	2.5	9.5
Testing effect	69.7	36.7	56.3
Class size	14.8	5.4	10.0

Note. A rigorous shift of opinion is defined as agreement to the statement ≥ 4 (for the testing effect ≥ 3) *before* and agreement to the statement ≤ 2 *after* reading a text about the current state of research.

Paper 2

This is the accepted version of the article

Menz, Cordelia, Spinath, Birgit, & Seifried, Eva (2021). Where Do Pre-Service Teachers' Educational Psychological Misconceptions Come From? The Roles of Anecdotal Versus Scientific Evidence. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000299

Where do pre-service teachers' educational psychological misconceptions come from? The roles of anecdotal versus scientific evidence

(69.862 characters)

Cordelia Menz[1*], Birgit Spinath[1] & Eva Seifried[1]

[*]corresponding author; Cordelia.Menz@psychologie.uni-heidelberg.de

[1]Heidelberg University, Department of Psychology, Hauptstraße 47-51, 69117 Heidelberg, Germany

Funding. This research project was financially supported by the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (Az: 33-7533.-30-10/25/63) and by the Excellence Initiative of the German Federal Government and the state governments – Funding line Institutional Strategy (Zukunftskonzept): DFG project number ZUK 49/Ü ("Heidelberg: Realising the Potential of a Comprehensive University"), and the language editing was funded by the Nachwuchspreis der Fachgruppe Pädagogische Psychologie (award for young researchers), awarded to Cordelia Menz in 2019.

Acknowledgment. We would like to thank Jane Zagorski for native speaker advice.

German Abstract

Bisherige Forschung weist auf eine hohe Prävalenz einiger (pädagogisch-)psychologischer Fehlvorstellungen (d. h. einem Glauben an falsche und verbreitete Annahmen, die wissenschaftlichen Erkenntnissen der Psychologie widersprechen) unter (angehenden) Lehrkräften hin. Allerdings ist die Anzahl der bisher untersuchten Themen begrenzt. Darüber hinaus kann es für die Bekämpfung von Fehlvorstellungen hilfreich sein, deren Quellen zu kennen. Da anekdotisches Wissen für professionelle Entscheidungen von (angehenden) Lehrkräften eine große Rolle spielt und persönliche Erfahrungen zu den am meisten genannten Quellen von Fehlvorstellungen gehören, nahmen wir an, dass angehende Lehrkräfte grundsätzlich vor allem anekdotische Quellen als Basis ihrer pädagogisch-psychologischen Überzeugungen nennen würden und sich diese auch als Hauptquelle ihrer pädagogisch-psychologischen Fehlvorstellungen im Speziellen erweisen würden. In einer Online-Befragung (mit sowohl korrelativen als auch quasi-experimentellen Elementen) an $N = 836$ Lehramtsstudierenden fanden wir einerseits, dass pädagogisch-psychologische Fehlvorstellungen weniger verbreitet waren als angenommen. Andererseits zeigte sich, dass die Lehramtsstudierenden ihre Überzeugungen tatsächlich hauptsächlich auf anekdotische Quellen (eigene oder stellvertretende Erfahrungen) zurückführten und dass sich diese auch als die Hauptquelle ihrer Fehlvorstellungen herausstellten (Vergleich mit wissenschaftlichen Quellen: $d = 0.19$ bzw. $d = 0.23$). Zusätzlich fanden wir, dass die vermehrte Nennung von anekdotischen Quellen im Vergleich zu wissenschaftlichen Quellen (Publikationen und Lehrveranstaltungen) als Ursprung von Überzeugungen mit unerwünschten Aspekten einherging, nämlich mit mehr Fehlvorstellungen ($d = 0.21$) und mit einer geringeren Reduktion von Fehlvorstellungen durch empirische widerlegende Texte ($d = 0.30$) – jedoch nicht mit einem geringeren Glauben an die wissenschaftliche Untersuchbarkeit pädagogisch-psychologischer Themen. Unsere Ergebnisse deuten insgesamt darauf hin, dass ein vermehrtes Verlassen auf anekdotische im Vergleich zu wissenschaftlichen Quellen mit

Aspekten assoziiert ist, die in Kontrast zu evidenzbasierter Bildung stehen. Zukünftige Forschung sollte untersuchen, weshalb sich angehende Lehrkräfte auf eigene oder stellvertretende Erfahrungen konzentrieren, wie man wissenschaftliche Quellen ansprechender gestalten kann und, ob eine Bekämpfung von Fehlvorstellungen durch das Aufzeigen von Nachteilen nicht-wissenschaftlicher Quellen effektiv ist.

Schlüsselwörter: Pädagogische Psychologie, Fehlvorstellungen, Lehramtsstudierende, Quellen von (Fehl-)Vorstellungen

English Abstract

Previous research has found a high prevalence of some (educational) psychological misconceptions (i.e., incorrect but often popular assumptions that contradict results from psychological research) among (pre-service) teachers. However, the number of topics that have been investigated is limited. Additionally, knowing the sources of misconceptions might be helpful for rebutting them. Furthermore, anecdotal evidence has been found to be important for informing (pre-service) teachers' practice, but personal experiences also are among the main sources of misconceptions. Therefore, we hypothesized that pre-service teachers would predominantly view sources of anecdotal evidence as the origin of their educational psychological beliefs in general and the main source of their misconceptions in particular. In an online survey (with correlational and quasi-experimental elements) of $N = 836$ pre-service teachers, we found that educational psychological misconceptions were less prevalent than expected but that pre-service teachers indeed mainly based their beliefs on sources of anecdotal evidence (personal experiences and narratives from other people) and that these nonscientific sources turned out to be the main sources of their misconceptions (comparison with scientific sources: $d = 0.19$ and $d = 0.23$). Furthermore, referring more to sources of anecdotal than scientific evidence (research and lectures) was associated with undesirable aspects, that is, more misconceptions ($d = 0.21$) and less reduction of

misconception endorsement through empirical refutation-style information (d = 0.30) but not with a lower judgment of the view that it is possible to examine educational psychological topics scientifically. In sum, our results indicate that basing one's beliefs more on sources of anecdotal than scientific evidence is associated with outcomes that stand in contrast to evidence-based education. Future research should investigate why pre-service teachers concentrate on sources of anecdotal evidence, how to make sources of scientific evidence more tempting, and whether counteracting misconceptions by showing the downside of nonscientific sources is effective.

Keywords: Educational Psychology, Misconceptions, Pre-service Teachers, Sources of Beliefs, Sources of Misconceptions

Background and Aims of the Study

Imagine a room of climatologists. How many will agree that human activity is a significant contributor to climate change? Research indicates that about 90% of these climate experts will probably agree with this claim (e.g., Doran & Zimmerman, 2009), which is in accordance with the current state of research. Now imagine a room of teachers. How many will agree that learning is enhanced when the presented information fits someone's preferred learning style? Research indicates that up to 96% of these education experts will agree with this claim (e.g., Dekker, Lee, Howard-Jones & Jolles, 2012), which is *not* in accordance with the current state of research. Such incorrect but often popular assumptions that are contradictory to results from psychological research are called psychological misconceptions (e.g., Bensley & Lilienfeld, 2015).

It is alarming that a large number of (pre-service) teachers[1] endorse the misconception about learning styles—an educational psychological topic that is important for teachers' professional lives. But do (pre-service) teachers also endorse misconceptions about other educational psychological topics? And to which sources do (pre-service) teachers attribute their beliefs about educational psychological topics? In particular, knowing the (perceived) source of misconceptions might be essential for the effective and enduring rebuttal of these misconceptions. While (pre-service) teachers have been found to prefer nonscientific anecdotal evidence in the form of personal experience and narratives from other people to inform their practice (e.g., Gitlin, Barlow, Burbank, Kauchak & Stevens, 1999; Hargreaves, 2000; Slavin, 2008), it has rarely been investigated whether such a tendency can also be found for (pre-service) teachers' knowledge acquisition or formation of beliefs. However, predominantly referring to such nonscientific sources might make (pre-service) teachers likely to fall prey to

[1]In the following, *(pre-service) teachers* refers to both pre- and in-service teachers. When only one group is addressed, they are identified as either *pre-service teachers* or *teachers*.

different biases and systematic distortion of thinking, resulting in incorrect knowledge and beliefs.

This study focuses on pre-service teachers and educational psychological topics; it investigates both the prevalence and subjective sources of pre-service teachers' beliefs about diverse topics from educational psychology, with a specific focus on sourcing from anecdotal evidence. The aims of the present study were (a) to assess the prevalence of diverse educational psychological misconceptions among pre-service teachers in Germany, (b) to gain insights into the (perceived) sources of pre-service teachers' beliefs about educational psychological topics in general and the beliefs that turned out to be misconceptions in particular, and (c) to analyze the correlates of relying more on nonscientific anecdotal sources than on scientific sources.

Educational Psychological Misconceptions Among Pre-service Teachers

In general, misconceptions have been defined as "inaccurate prior knowledge" (Taylor & Kowalski, 2014; p. 259) and "false, common-sense beliefs" (Bensley & Lilienfeld, 2015, p. 283). Thus, in the psychological context, the term *misconception* is used to refer to both knowledge and beliefs that are at odds with the current scientific state of psychological research (see the review by Hughes, Lyddy & Lambe, 2013). Psychological misconceptions have been studied for decades (e.g., McCutcheon, 1991; Vaughan, 1977), mostly in psychology students and the general population. Among these groups, psychological misconceptions have been found to be highly prevalent (e.g., Furnham & Hughes, 2014; Hughes et al., 2015; Lilienfeld, Lynn, Ruscio & Beyerstein, 2010; McCutcheon, 1991; Taylor & Kowalski, 2004; Vaughan, 1977).

Recently, the target groups have been expanded to include (pre-service) teachers and the topics to include educational psychological misconceptions (e.g., Menz, Spinath & Seifried, 2020; Pieschl, Archer & Budd, 2019). This is a meaningful enhancement because throughout their careers, teachers are distributors of knowledge, and they are expected to build on what

they have learned during teacher training. Therefore, it is essential to focus on pre-service teachers to set the stage for a science-oriented use of educational psychological knowledge in teachers' daily lives. If incorrect prior knowledge or beliefs contradict new information, conceptual change is needed (for an overview of conceptual change theories, see Tippett, 2010). Refutation-style texts (i.e., activating a misconception and directly refuting it by combining correct information with explanations; see Lassonde, Kolquist & Vergin 2017) are promising for achieving conceptual change (see e.g., Mason et al., 2017; Tippett, 2010; for a detailed description of how refutation-style texts support conceptual change, see also Richter & Singer, 2017). Conversely, if conceptual change is not achieved, learning can be impaired by incorrect prior knowledge or beliefs, that is, by misconceptions (e.g., Kendeou & van den Broek, 2005; Prinz, Golke & Wittwer, 2018, 2019). Besides the negative effect of misconceptions on someone's own learning, misconceptions should be prevented or combatted particularly among (pre-service) teachers to avoid an unwanted propagation of misconceptions. In this regard, the impact of teachers is enormous because they communicate with many people during their professional activities and, as educational experts (see KMK, 2004), they can be perceived as a trustworthy source of information on educational topics. Additionally, if (pre-service) teachers have educational psychological misconceptions, this could lead to serious misjudgments in their professional environment (see also Pasquinelli, 2012). Consequently, the influence of teachers' educational psychological misconceptions can hardly be overrated, and therefore, such misconceptions should be prevented as early as possible (i.e., during pre-service teachers' training). If misconceptions are not prevented from forming during scientific education at universities, it is less likely that they ever will be prevented because teachers have been found to devalue theory and to seldom refer to sources of research knowledge (see e.g., Allen, 2009). Thus, investigating pre-service teachers' educational psychological misconceptions is particularly relevant for the educational sector.

International studies indicate that one educational psychological misconception—the abovementioned learning styles misconception—is extremely widespread among (pre-service) teachers: Its prevalence varies from 82% in the United Kingdom (Howard-Jones, Franey, Mashmoushi & Liao, 2009) to above 90% in Australia, Germany, the Netherlands, and Turkey (Dekker et al., 2012; Dündar & Gündüz, 2016; Menz et al., 2020; Pieschl et al., 2019). In a recent study, we also investigated the prevalence of further educational psychological misconceptions among pre-service teachers in Germany and found that misconceptions about the existence of multiple intelligences (88.2%) and the impact of class size on student learning (85.6%) were also highly prevalent (Menz et al., 2020; for the prevalence of further educational psychological misconceptions among pre-service teachers in Australia, see Pieschl et al., 2019).

In sum, previous research has shown that some educational psychological misconceptions are highly prevalent among (pre-service) teachers. However, the range of topics that have been investigated is limited. In this study, we therefore investigated the prevalence of misconceptions about 14 educational psychological topics that play an important role in the future work of pre-service teachers (Research Question 1; RQ1) and also examined the sources of pre-service teachers' beliefs regarding these topics in general and about the beliefs that turned out to be misconceptions in particular. In the following, we use the term *beliefs* to refer to the entirety of beliefs that someone possesses and the term *misconceptions* to refer to the subset of beliefs that turned out to be wrong.

Pre-service Teachers' Sources of Beliefs and Misconceptions About Educational Psychological Topics

In general, sources of beliefs about psychological topics can be manifold. Often, the media are seen as an important source of psychological misconceptions (e.g., Chew, 2006; Gardner & Dalsing, 1986; Lilienfeld, 2005; Taylor & Kowalski, 2004). Other potential sources are common sense (e.g., Hughes et al., 2013), personal experience (e.g., Gaze, 2014; Taylor &

Kowalski, 2004), narratives from other people or personal contact (e.g., Gardner & Dalsing, 1986; Landau & Bavaria, 2003), lectures (e.g., Chew, 2006; Landau & Bavaria, 2003; Taylor & Kowalski, 2004), and publications (e.g., Higbee & Clay, 1998). However, studies usually rely on self-reported sources, that is, the sources participants (believe they) remember when asked about the origin of their beliefs.

For (pre-service) teachers, personal or vicarious experiences can be expected to be very relevant for the formation of beliefs about educational psychological topics for several reasons. First, everyone has attended school and thereby possesses a history of experiences and probably vivid examples of anecdotal evidence from the educational sector. Second, educational research is often perceived as not applicable to the classroom (e.g., Vanderlinde & van Braak, 2010, see also review by van Schaik, Volman, Admiraal & Schenke, 2018). Third and consequently, nonscientific anecdotal sources have already been found to be important for (pre-service) teachers' decisions and actions (e.g., Dagenais et al., 2012).

Previous research indicates that pre-service teachers believe experience is more important than research, and when asked about possible resources for their decision-making, they name (other) teachers (Gitlin et al., 1999). While Ingram, Louis and Schroeder (2004) reported that their sample of teachers based their decisions equivalently on unsystematic and systematic data, the teachers in another sample claimed that they base their decisions on their experience as teachers instead of data (Schildkamp & Kuiper, 2010). Furthermore, in a qualitative study, (pre-service) teachers predominantly named informal sources (i.e., observational, enactive, or collaborative experiences) when asked about where their knowledge about how to teach comes from (Buehl & Fives, 2009). Thus, previous research indicates that (pre-service) teachers prefer and use anecdotal evidence to inform their practice, and there is initial evidence for an analogous tendency in (pre-service) teachers' beliefs about teaching knowledge. Therefore, we hypothesized that nonscientific experiential sources, that is,

anecdotal evidence, are also relevant for pre-service teachers' beliefs about educational psychological topics in general. As *anecdotal evidence*, we include both personal observations and narratives from others, that is, personal or vicarious experiences (see also classification of *experiential sources* by Bråten & Ferguson, 2015).

Obviously, anecdotal evidence can lead to correct representations about different issues in some cases. However, there is good reason to expect that not only pre-service teachers' beliefs about educational psychological topics in general but also their educational psychological misconceptions in particular might be attributed to sources of anecdotal evidence. This is because first- or second-hand experiences are usually nonsystematic and therefore misleading. Although they can be perceived as very vivid and memorable—and therefore seductive—anecdotal evidence is based on individual experiences or small sample sizes with doubtful representativeness (see Lilienfeld, Ammirati & David, 2012). Narrative persuasion (see Appel & Richter, 2007) is one reason for why personal or vicarious experiences may be misleading: Richter, Schroeder and Wöhrmann (2009) argued that people "who are mentally transported into the fictitious world of the narrative are subject to a temporary suspension of disbelief that makes them susceptible to implicit persuasion" (p. 552). Additionally, personal and vicarious experiences are prone to being sources of misconceptions due to different cognitive biases. For example, laboring under the confirmation bias (i.e., the tendency to seek predominantly information that satisfies prior expectations) can form or encourage misconceptions (see Chew, 2006; Gilovich, 1991).

In sum, there are various possible sources of beliefs and misconceptions about psychological issues, and when referring to educational psychological topics, anecdotal evidence might play a particularly important role for pre-service teachers. But whether or not anecdotal evidence is the primary source of pre-service teachers' beliefs and misconceptions about specific topics from educational psychology has not been investigated in detail. However,

on the basis of the aforementioned theoretical argumentation and previous empirical studies, we hypothesized that anecdotal evidence would be named more often than scientific evidence as the source of both pre-service teachers' beliefs about educational psychological topics in general (H2a) and their educational psychological misconceptions in particular (H2b).

Primarily Sourcing from Anecdotal Versus Scientific Evidence

In contrast to anecdotal evidence, scientific empirical evidence is based on diverse samples and sound methodology, leading to more robust results for different contexts. Even though empirical evidence might change over time, using scientific information is generally considered a desirable approach that is reflected in common standards for teacher education (see e.g., Commission of the European Communities, 2007; KMK, 2004). Thus, while anecdotal evidence legitimately contributes to teachers' professional lives, they should primarily rely on scientific evidence (see also calls for evidence-based practice; e.g., Dunn, Saville, Baker & Marek, 2013; Slavin, 2002). It is not that (pre-service) teachers should not use anecdotal evidence at all, but rather that the ratio of relying on scientific versus anecdotal evidence might be important. Thus, a tendency to rely primarily on anecdotal evidence over scientific evidence might be associated with various undesirable aspects.

First, primarily basing one's beliefs on anecdotal evidence might result in a larger number of misconceptions. Misconceptions are interchangeably called "nonscientific ideas" (e.g., Hamza & Wickman, 2008, p. 142) or "discipline-inconsistent prior knowledge" (Hughes et al., 2013, p. 21), and psychological misconceptions have often been found to derive from personal experiences in everyday life (e.g., Hughes et al., 2013). Thus, pre-service teachers who rely primarily on anecdotal sourcing (i.e., those who base their beliefs more on anecdotal than on scientific sources; primarily anecdotal-sourcing) can be expected to endorse more misconceptions than those who rely primarily on scientific sourcing (i.e., those who base their beliefs more on scientific than on anecdotal sources; primarily scientific-sourcing).

Second, not only might primarily anecdotal-sourcing pre-service teachers endorse more misconceptions, but their misconceptions might also be more challenging to reverse by presenting empirical evidence. In a previous study, we focused on the beneficial effects of refutation-style texts. We found that empirical refutation-style texts were superior to anecdotal refutation-style texts in reducing pre-service teachers' educational psychological misconceptions. However, after reading an empirical refutation-style text, only 15-22% (of more than 800 pre-service teachers) showed a drastic change in their misconceptions (i.e., from [rather or strong] agreement with the wrong thesis before reading the refutation-style text to [rather or strong] disagreement after reading the refutation-style text; Menz et al., 2020). Perhaps the reduction in misconceptions through empirical refutation-style information depends on the kinds of sources pre-service teachers prefer. If someone sources more from nonscientific anecdotal evidence than from scientific empirical evidence, reading an empirical refutation-style text might not be very effective at reducing a specific misconception. This should be the case because, if scientific empirical evidence was convincing for these people, they would be expected to name it more often as the source of their beliefs. Additionally, the corresponding misconceptions could be consolidated because they have been formed through repeated personal or vicarious experiences (i.e., confirmation bias). In this case, one short empirical text might not be sufficient for combatting the preexisting worldview.

Third, primarily anecdotal-sourcing pre-service teachers might have a specific negative attitude toward scientific evidence, for example, they might judge science as not suitable for examining specific educational questions (see e.g., Cain, 2016; see also Munro, 2010, who investigated the scientific impotence discounting hypothesis as a possible explanation for people disagreeing with scientific statements within a broader scope). Therefore, some pre-service teachers might focus on sources of anecdotal evidence because they believe that science is not appropriate for examining educational topics.

In sum, these considerations indicate that different undesirable aspects might be associated with sourcing primarily from anecdotal evidence. Thus, we hypothesized that, compared with primarily scientific-sourcing pre-service teachers, primarily anecdotal-sourcing pre-service teachers would endorse more educational psychological misconceptions (H3a), change their misconceptions about educational psychological topics less when confronted with the current state of research in an empirical format (H3b), and judge educational psychological topics as less scientifically examinable (H3c).

Methods and Materials

In this study, we conducted an online survey on the prevalence of pre-service teachers' misconceptions about 14 educational psychological topics (RQ1) and, to test our hypotheses about the primary sources of our participants' beliefs and misconceptions about these educational psychological topics, we used a design with both correlational (H2) and quasi-experimental elements (H3); details are described in the following.

Data Collection

An online survey presented via *SoSci Survey* was used to collect data from September to December 2018. Pre-service teachers from all federal states in Germany were contacted and informed about the survey via posts in social media groups for pre-service teachers. The only requirement for participating was enrollment in an academic teacher education program at a German university. Participation was completely voluntary, and participants were immediately informed that they could leave the study at any time and that their data would remain anonymous. After completing the survey, all participants could enter a lottery for 20 drawings of 50€ each.

Participants

The final sample consisted of $N = 836$ pre-service teachers (77.4% women). Their mean age was $M = 23.07$ years ($SD = 3.74$), and on average, participants were in their sixth semester of study ($M = 6.10$, $SD = 3.65$). During their studies, only 6.9% of the sample had never taken an educational science course, while 5.6% had taken one course, 11.1% two, 12.6% three, and 63.8% four or more educational science courses. No participants had to be excluded, and due to the settings of the survey, there were no missing data.

Materials

Educational psychological topics. To investigate the prevalence of educational psychological misconceptions, we selected 14 educational psychological topics that are important for pre-service teachers and their professional lives. In line with the previous sections, we use the term *beliefs* when referring to participants' evaluations of all 14 topics, independent of whether these evaluations turned out to be right or wrong. However, when referring only to the portion of participants' beliefs that turned out to be wrong, we use the term *misconceptions* (to represent the subset of their beliefs including only incorrect evaluations). Thus, participants endorsed a misconception when they rather or very much agreed with a statement that was in conflict with the current state of research or rather or very much disagreed with a statement that was in accordance with the current state of research.

Eight of the topics (e.g., about multitasking, the learning pyramid, or the benefits of single-sex education) were chosen from the book *Urban Myths about Learning and Education* (de Bruyckere, Kirschner & Hulshof, 2015). Other topics (e.g., about the nonvariability of intelligence) were chosen because they are often misunderstood in lectures for pre-service teachers at our university (unpublished data). Other topics (e.g., about the percentage of the brain that is used or the origins of ADHD) were chosen because international studies indicate that misconceptions about these topics are prevalent in other samples (Ghanizadeh, Bahredar

& Moeini, 2006; Hermida, Segretin, Soni García & Lipina, 2016). English translations of the 14 items are displayed in Appendix A.

Participants read one statement about each topic and indicated their agreement with this statement on a 5-point scale (1 = *I do not agree at all*; 5 = *I agree very much*). Of these 14 statements, nine were formulated to be contrary to and five were formulated to be in accordance with the current state of research.

Sources of beliefs and misconceptions about educational psychological topics. To investigate the sources of pre-service teachers' beliefs about educational psychological topics in general and of their misconceptions in particular, participants indicated what source(s) they based their beliefs on for each of the 14 statements. Because it is possible for multiple sources to exist simultaneously (see Buehl & Fives, 2009), participants could select one to six different source(s) for each statement. To consider the relative importance of each source, participants were asked to distribute 6 points to one or more sources, depending on how important each source was for their decision about the statement. We chose six different sources from previous literature (e.g., Bråten & Ferguson, 2015; Taylor & Kowalski, 2004) and an unpublished pilot study. In alphabetical order, the sources were common sense, lectures, media, narratives from other people, personal experience, and scientific research. In addition, participants could choose "other"/"I can't name the source" and use an open text field to indicate the other source if applicable. Related to the investigation by Bråten and Ferguson (2015), we combined the sources narratives from other people and personal experience to build the category of sources of anecdotal evidence, and we combined the sources lectures and scientific research to build the category of sources of scientific evidence. Thus, the sources common sense, media, and the option "other/"I can't name the source" were not assigned to any of the closely investigated categories in this study.

Empirical refutation-style text. To measure the change in educational psychological misconceptions from reading empirical refutation-style texts, we used the most prevalent misconception (i.e., about learning styles) and the empirical refutation-style text from a previous study (Menz et al., 2020). Participants first indicated their agreement with the following statement: "How much do you agree with the thesis that there are different learning styles (e.g., auditory, visual, or kinesthetic) that enable more effective learning?" on a 5-point scale (1 = *I do not agree at all*; 5 = *I agree very much*). Afterwards, they read a short refutation-style text that presented the current state of research as a summary of empirical findings and that clearly contradicted the idea that there are different learning styles that enable more effective learning. Following the reading of the text, participants were asked how much they *now* agreed with the aforementioned statement using the same scale. For a more detailed description of the refutation-style text, see Menz et al. (2020).

Possibility that educational psychological topics can be examined scientifically. To measure whether pre-service teachers judged educational psychological topics as scientifically examinable, we formulated statements concerning three educational psychological topics (i.e., the effectiveness of learning styles, the existence of multiple intelligences, and the impact of class size on student learning) about which misconceptions were shown to be prevalent in our previous study (Menz et al., 2020). Each statement's wording was based on the wording used by Munro (2010) who investigated the scientific impotence discounting hypothesis. For instance, the statement concerning learning styles was "The question of whether there are different learning styles (e.g., auditory, visual, or kinesthetic) that enable more effective learning is one that cannot be answered using scientific methods." For each statement, participants indicated their agreement on a 5-point scale (1 = *I do not agree at all*; 5 = *I agree very much*).

Procedure

After the pre-service teachers had provided informed consent to participate in this study and sociodemographic data, they answered the questionnaire, which took about 20 minutes to complete. To address RQ1 (i.e., prevalence of different educational psychological misconceptions), participants indicated their agreement with 14 topics from educational psychology. To address our hypotheses related to pre-service teachers' sources of beliefs and misconceptions about educational psychological topics, participants indicated the origin of their evaluations. Furthermore, participants indicated their agreement with a frequently examined educational psychological misconception (i.e., the misconception about learning styles), read one short refutation-style text that used empirical findings to refute the misconception, and then indicated their agreement with the misconception again (see Menz et al., 2020). At the end, participants indicated how scientifically examinable they perceived three educational psychological topics to be.

Statistical Analyses

We used the program IBM SPSS Statistics (version 25) for all statistical analyses. To address RQ1, we considered the prevalence of the investigated misconceptions. To test our specific hypotheses, we computed dependent-samples *t*-tests (H2a and H2b), independent-samples *t*-tests (H3a and H3c), and a repeated-measures analysis of variance (H3b). For the analyses regarding H3a-H3c, we divided the sample into primarily anecdotal-sourcing pre-service teachers and primarily scientific-sourcing pre-service teachers.

Results

In the following, we first refer to the prevalence of misconceptions about the 14 investigated educational psychological topics. For every topic, Table 1 presents the frequencies for each response category (i.e., level of agreement). Afterwards, results on the sources of pre-service teachers' beliefs about educational psychological topics in general and of their

misconceptions in particular are displayed. Finally, results concerning different correlates of sourcing more from anecdotal than from scientific evidence are presented.

Prevalence of Educational Psychological Misconceptions

To investigate whether and to what extent misconceptions about the 14 chosen educational psychological topics are prevalent among pre-service teachers, we refer to the data on a descriptive level. Endorsing a misconception was defined as *rather* or *very much* agreeing (i.e., agreement ≥ 4) with a claim that was not in accordance with the current state of research or *rather not* or *not at all* agreeing (i.e., agreement ≤ 2) with a claim that was in accordance with the current state of research (see Hughes et al., 2015; Menz et al., 2020). The number of misconceptions per person ranged from zero to eleven (M = 4.74, SD = 1.77). For seven topics, more than one third of the pre-service teacher sample endorsed a misconception. For three of these topics, more than half of the pre-service teacher sample endorsed a misconception (for further details, see Table 1). Exploratory post hoc analyses indicated that the number of courses taken (r = -.08, p = .022) and students' semester (r = -.12, p = .001) were negatively correlated with the number of misconceptions.

[*Table 1*]

Sources of Beliefs and Misconceptions About Educational Psychological Topics

The descriptive statistics presented in Table 2 show the average percentage of possible points pre-service teachers distributed to each of the six specific sources and the category "other"/"I can't name the source" as well as the aggregate of anecdotal and scientific sources for their beliefs and misconceptions about educational psychological topics (for a detailed description of the corresponding data for each topic, see Table 3). To investigate whether pre-service teachers named more sources of anecdotal evidence than scientific evidence as the origin of their beliefs about educational psychological topics in general, we computed a

dependent-samples *t*-test. There was a significant difference between the percentage of points distributed to sources of anecdotal (M = 32.68, SD = 0.16) versus scientific evidence (M = 27.21, SD = 0.17), $t(835) = 5.492$, $p < .001$, $d = 0.19$.

[*Table 2*]

[*Table 3*]

To investigate whether pre-service teachers named more sources of anecdotal evidence than scientific evidence as the origin of their educational psychological misconceptions, we computed another dependent-samples *t*-test. In this analysis, participants' data were only included when participants endorsed a misconception about a topic. There was a significant difference between the number of points distributed to sources of anecdotal (M = 35.95, SD = 0.22) versus scientific evidence (M = 27.15, SD = 0.21), $t(832) = 6.808$, $p < .001$, $d = 0.23$. Thus, pre-service teachers based their beliefs about educational psychological topics more on sources of anecdotal evidence than on sources of scientific evidence, and this was also true for the portion of their beliefs that turned out to be misconceptions.

Primarily Sourcing from Anecdotal Evidence

To analyze whether different undesirable aspects are associated with basing one's beliefs more on anecdotal than on scientific evidence, participants were either classified as primarily anecdotal-sourcing (i.e., distributing more points to anecdotal than to scientific evidence) or as primarily scientific-sourcing (i.e., distributing more points to scientific than to anecdotal evidence). On the basis of this definition, 495 participants were classified as primarily anecdotal-sourcing and 323 participants as primarily scientific-sourcing. Eighteen participants could not be classified and were therefore excluded from the following analyses.

Regarding the first aspect of interest—whether primarily anecdotal-sourcing pre-service teachers endorse more misconceptions than primarily scientific-sourcing pre-service teachers—

an independent-samples *t*-test showed a significant difference between primarily anecdotal-sourcing (M = 4.89, SD = 1.75) and primarily scientific-sourcing pre-service teachers (M = 4.53, SD = 1.76), $t(816) = 2.897$, $p = .004$, $d = 0.21$. Thus, primarily anecdotal-sourcing pre-service teachers endorsed more misconceptions than primarily scientific-sourcing pre-service teachers.

Regarding the second aspect of interest—whether primarily anecdotal-sourcing pre-service teachers change their misconceptions less after reading an empirical refutation-style text than primarily scientific-sourcing pre-service teachers—a 2 (anecdotal-sourcing vs. scientific-sourcing) x 2 (before vs. after reading the refutation-style text) repeated-measures ANOVA was computed. For this analysis, only participants endorsing a misconception about the effectiveness of learning styles (i.e., indicating an agreement ≥ 4 with the corresponding statement) were included, leading to a sample of N = 763 participants (n = 473 primarily anecdotal-sourcing pre-service teachers, n = 290 primarily scientific-sourcing pre-service teachers). There was a statistically significant main effect of sourcing type, $F(1, 761) = 9.841$, $p = .002$, $d = 0.23$, and of time, $F(1, 761) = 512.774$, $p < .001$, $d = 1.64$. Additionally, there was a statistically significant interaction effect, $F(1, 761) = 8.682$, $p < .001$, $d = 0.30$. Simple effects analyses following up on the significant interaction indicated that there was no difference in misconception endorsement between the groups at t1 (p = .878) but that misconception endorsement was lower among primarily scientific-sourcing pre-service teachers than among primarily anecdotal-sourcing pre-service teachers at t2, $p < .001$, $d = 0.28$. This indicates a more pronounced misconception reduction after reading the refutation-style text for primarily scientific-sourcing pre-service teachers (M_{pre} = 4.73, SD_{pre} = 0.44; M_{post} = 3.73, SD_{post} = 1.10) than for primarily anecdotal-sourcing pre-service teachers (M_{pre} = 4.73, SD_{pre} = 0.45; M_{post} = 4.04, SD_{post} = 1.04). As in our previous study (Menz et al., 2020), we also analyzed how many pre-service teachers showed a drastic change in their misconception (i.e., agreement of ≥ 4 before and agreement of ≤ 2 after reading the refutation-style text). Among the primarily scientific-sourcing pre-service teachers, 18.3% drastically changed their misconception about

learning styles, whereas among the primarily anecdotal-sourcing pre-service teachers, only 10.1% did so.

Regarding the third aspect of interest—whether primarily anecdotal-sourcing rather than primarily scientific-sourcing pre-service teachers judge educational psychological topics as less scientifically examinable—an independent-samples *t*-test showed no significant difference between primarily anecdotal-sourcing ($M = 2.26$, $SD = 0.74$) and primarily scientific-sourcing pre-service teachers ($M = 2.17$, $SD = 0.81$), $t(816) = 1.527$, $p = .127$. Thus, there was no indication of a different judgment regarding the possibility that educational topics could be examined scientifically between the groups.

Discussion

The central aim of this study was to extend knowledge about pre-service teachers' educational psychological misconceptions. We focused on both the prevalence of diverse misconceptions and their sources and the specific role of anecdotal compared with scientific information sources. Furthermore, we also analyzed possible correlates of predominantly relying on anecdotal sources. Thereby, we aimed to gather information on how many and which misconceptions need to be combatted among pre-service teachers and how to do so effectively because people who base their beliefs on anecdotal sources might respond to different forms of refutations than those who base their beliefs on scientific sources.

First, we investigated the prevalence of educational psychological misconceptions (RQ1) with a set of 14 educational psychological topics. Thus, with this study, we broadened the spectrum of previously investigated educational psychological topics. We found a large range of misconception endorsement (varying between 9.3% and 71.9% per topic), with prevalence rates below 33.3% for half of the topics. This finding shows that the distribution of misconceptions is topic specific (see also e.g., Pieschl et al., 2019) and might also be dependent on item wording (see Hughes et al., 2013). One reason for some low prevalence rates could be

grounded in the large number of educational science classes taken by our sample: Both the number of courses taken and students' semester were negatively correlated with the number of pre-service teachers' misconceptions. This finding points to the possibility that continuously being confronted with scientific findings through teacher training might result in a reduction in educational psychological misconceptions (see also Kowalski & Taylor, 2009), possibly also overriding strongly held anecdote-based beliefs. However, some other misconceptions were alarmingly widespread: For four of our 14 topics, more than one third of the pre-service teacher sample endorsed a misconception, and for another three topics, the prevalence even exceeded 50%. Pasquinelli (2012) argued that educational psychological misconceptions among teachers could lead to misdirected financial investments and time input during their professional lives. Hence, it is debatable whether the prevalence of misconceptions found in our study should be interpreted as a relief (regarding the low prevalence rates of some misconceptions) or as a concern (in light of possible consequences).

Moreover, we investigated which sources pre-service teachers based their beliefs and misconceptions about educational psychological topics on. In line with our hypotheses, pre-service teachers indeed named more sources of anecdotal than scientific evidence as the origin of their beliefs about the 14 investigated educational psychological topics in general (H2a) as well as the portion of their beliefs that turned out to be wrong, that is, misconceptions (H2b) (albeit with small effect sizes, see Cohen, 1988). Our study extends previous research by showing that (pre-service) teachers not only indicate that they prefer and use anecdotal evidence to make decisions (e.g., Gitlin et al., 1999; Hargreaves, 2000; Schildkamp & Kuiper, 2010), but they also frequently named sources of anecdotal evidence when asked about the sources they based their beliefs and misconceptions about different educational psychological topics on. On the one hand, this finding is consistent with previous studies that indicated that personal experiences are among the most frequently named sources of misconceptions (e.g., Gaze, 2014; Taylor & Kowalski, 2004). In this study, they in fact comprised the relative majority of sources

that pre-service teachers named as the origin of their misconceptions for most of the topics. On the other hand, this finding is inconsistent with previous assumptions and findings about further sources of misconceptions because, for example, we found that the media played a rather minor role in the development of educational psychological misconceptions (cf. de Bruyckere et al., 2015; Lilienfeld, 2005; Taylor & Kowalski, 2004). Interestingly, when directly comparing the ratio of sourcing from scientific versus anecdotal evidence only, nearly 40% of our pre-service teacher sample was classified as primarily scientific-sourcing (i.e., they indicated that they derived their beliefs more from scientific than from anecdotal sources). This relatively high percentage would not have been expected on the basis of previous findings that indicated that (pre-service) teachers prefer anecdotal over scientific evidence (e.g., Bråten & Ferguson, 2015; Buehl & Fives, 2009). However, it can be interpreted as positive from a lecturer's or researcher's perspective because it indicates that (at least pre-service) teachers in fact do name scientific sources as the origin of their beliefs, a finding that is in line with the goals of teacher education (see e.g., Commission of the European Communities, 2007; KMK, 2004). While it was not the main focus of our study, we found that the source attributions for the beliefs in general and those that turned out to be wrong (i.e., pre-service teachers' misconceptions) were remarkably similar. Although pre-service teachers' misconceptions are a subset of their beliefs (and thus, they are confounded), the resemblance of the source attributions is an interesting finding regarding pre-service teachers' general source preferences and what they can result in, namely, both correct and incorrect knowledge or beliefs.

In this regard, pre-service teachers' sourcing from lectures is worth looking at: Even though in absolute terms, sources of anecdotal evidence were named more often than sources of scientific evidence, lectures were also frequently named as a source of pre-service teachers' beliefs. At first glance, this is a positive result regarding pre-service teachers' experience with educational science classes: They feel they have learned something in these courses. However, taking a deeper look at our findings, lectures were descriptively named even more frequently

when considering the sources of pre-service teachers' misconceptions only. This finding can be interpreted in different ways: Quite likely, pre-service teachers have misunderstood or misinterpreted the content they have been taught in their classes. However, it might also be possible that lecturers have taught content that is not in accordance with the current state of research or that, in the meantime, more published evidence contradicts what the lecturers have taught before. Either way, if students think they have learned something in their educational science courses, but it is not consistent with the current state of research, we probably have to think about the way we convey scientific findings so that they are understood and remembered correctly—and continuously adapted to the current state of knowledge. However and in general, it is important to keep in mind that the named sources do not necessarily represent the actual sources of beliefs (for this limitation, see below).

Another aim of this study was to investigate whether using more anecdotal than scientific evidence to base one's beliefs on comes with undesirable aspects. In line with our hypotheses, we found that primarily anecdotal-sourcing pre-service teachers endorsed more misconceptions (H3a) and were less convinced by scientific information when confronted with belief-inconsistent empirical refutation-style information than primarily scientific-sourcing pre-service teachers (H3b) (albeit again with small effect sizes). Contrary to H3c, there was no difference regarding the perception that it is possible to examine educational psychological topics scientifically. These findings may be interpreted as possible support for our claim that sourcing from anecdotal evidence would both be a substantial origin of misconceptions and possibly impair the effects of refutations with empirical evidence. Due to the design of our study, however, it is impossible to determine whether sourcing primarily from anecdotal evidence causes people to endorse more misconceptions and renders them more difficult to convince with empirical information. At least potentially, people who endorse more misconceptions or who are more difficult to convince with empirical information could avoid scientific sources or a third factor could determine both. Although primarily anecdotal- and

scientific-sourcing pre-service teachers did not differ in their judgment of whether it is possible to examine educational psychological topics scientifically, their agreement with this statement was rather moderate on average. Thus, in sum, these findings corroborate the importance of giving pre-service teachers an understanding of how science works to make scientific sources more convincing and tempting for them.

Limitations

The first limitation of this study concerns the small effect sizes. Consequently, the practical relevance of the findings is restricted. However, we think that also small effects can make a difference in everyday school life if teachers do or do not endorse a misconception and act accordingly (for the relevance of small effects, see also Funder & Ozer, 2019). Even though we analyzed a variety of educational psychological topics, this still represents a limited selection of the range of possible topics. Thus, the findings about the prevalence rates and the sources of pre-service teachers' beliefs in general and their misconceptions in particular are valid only for these specific topics and can therefore not be generalized. In addition, it might be possible that participants' responses differ as a function of topic or individual differences. Topic was not included as a factor in our analyses because we did not have any a priori expectations about its influence. However, future research should investigate whether specific topics are prone to becoming misconceptions and being based on either anecdotal or scientific evidence (as well as the underlying characteristics of these topics). In addition, it could be worthwhile to examine individual differences because some people might be more prone to endorsing misconceptions than others (and again, the common characteristics of these people could be analyzed). Furthermore, the influence of the wording of the statements on misconception endorsement is not clear. In addition, one could question whether the low prevalence of false beliefs for some topics should be interpreted as misconceptions because sometimes, misconceptions are defined as incorrect assumptions that are *popular* (e.g., Bensley &

Lilienfeld, 2015). However, in a more recent study, the same authors (2017) argued that commonsense and false beliefs about different psychological topics must logically be seen as psychological misconceptions, irrespective of their frequency, and we agree with this interpretation. Another limitation might be seen in the fact that the sources in this study were indicated in the form of a retrospective self-report, and sometimes people do not correctly remember the real source of their beliefs (see Marsh, Cantor & Brashier, 2016). Thus, it is unclear whether the subjective sources (i.e., the sources that are reported) are also the real sources of one's beliefs in general and one's misconceptions in particular. Nevertheless, to refute misconceptions, the real sources might be less important than the subjective sources. If pre-service teachers believe they learned something in their university classes, this could make a misconception stick, independent of where they actually got this incorrect information from. Refuting such a subjectively scientifically based misconception might require a different form of refutation than a subjectively anecdotally based misconception (e.g., fostering pre-service teachers' critical thinking skills to enable them to detect possible biases in their personal experiences vs. fostering pre-service teachers' methodological skills to enable them to derive correct conclusions from empirical studies or to raise their awareness of the fact that empirical evidence is preliminary and can change over time). Another limitation of this study is that we assessed only undesirable cognitive aspects. It would deepen our knowledge to find out whether sourcing more from anecdotal than scientific evidence is also associated with behavioral aspects, for example, using scientific information or data in the classroom.

Conclusion

(Pre-service) teachers will have an enormous impact on many people. Thus, it is important to know more about their educational psychological misconceptions. This study indicates that pre-service teachers might have different educational psychological misconceptions, that they might primarily base their beliefs about different educational

psychological topics on anecdotal sources, and that sourcing more from anecdotal than from scientific evidence might be associated with undesirable aspects. For future research, it would be interesting to consider topic-specific differences because the varying frequency of misconception endorsement across topics in our study might point to possible variations across topics. By investigating the sources of pre-service teachers' beliefs in general and their misconceptions in particular, we believe that the present study can serve as a first reference point from which to investigate how to combat pre-service teachers' educational psychological misconceptions efficiently.

References

Allen, J. M. (2009). Valuing practice over theory: How beginning teachers re-orient their practice in the transition from the university to the workplace. *Teaching and Teacher Education, 25*, 647–654. doi:10.1016/j.tate.2008.11.011

Appel, M. & Richter, T. (2007). Persuasive effects of fictional narratives increase over time. *Media Psychology, 10*, 113–134. doi:10.108/15213260701301194

Bensley, D. A. & Lilienfeld, S. O. (2015). What is a psychological misconception? Moving toward an empirical answer. *Teaching of Psychology, 42*, 282–292. doi:10.1177/0098628315603059

Bensley, D. A. & Lilienfeld, S. O. (2017). Psychological misconceptions: Recent scientific advances and unresolved issues. *Current Directions in Psychological Science, 26*, 377–382. doi:10.1177/0963721417699026

Bråten, I. & Ferguson, L. E. (2015). Beliefs about sources of knowledge predict motivation for learning in teacher education. *Teaching and Teacher Education, 50*, 13–23. doi:10.1016/j.tate.2015.04.003

Buehl, M. M. & Fives, H. (2009). Exploring teachers' beliefs about teaching knowledge: Where does it come from? Does it change? *Journal of Experimental Education, 77*, 367–407. doi:10.3200/JEXE.77.4.367-408

Cain, T. (2016). Research utilisation and the struggle for the teacher's soul: A narrative review. *European Journal of Teacher Education, 39*, 616–629. doi:10.1080/02619768.2016.1252912

Chew, S. L. (2006). Seldom in doubt but often wrong: Addressing tenacious student misconceptions. In D. S. Dunn & S. L. Chew (Eds.), *Best practices for teaching introduction to psychology* (pp. 211–224). New Jersey: Lawrence Erlbaum Associates.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Commission of the European Communities (2007). *Communication from the commission to the council and the European parliament. Improving the quality of teacher education.* Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52007DC0392

Dagenais, C., Lysenko, L., Abrami, P. C., Bernard, R. M., Ramde, J. & Janosz, M. (2012). Use of research-based information by school practitioners and determinants of use: A review of empirical research. *Evidence & Policy, 8,* 285–309. doi:10.1332/174426412X654031

de Bruyckere, P., Kirschner, P. A. & Hulshof, C. D. (2015). *Urban myths about learning and education*. London: Elsevier.

Dekker, S., Lee, N. C., Howard-Jones, P. & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology, 3*(429), 1–8. doi:10.3389/fpsyg.2012.00429

Doran, P. T. & Zimmerman, M. K. (2009). Examining the scientific consensus on climate change. *Eos, Transactions American Geophysical Union, 90,* 22–23. doi:10.1029/2009EO030002

Dunn, D. S., Saville, B. K., Baker, S. C. & Marek, P. (2013). Evidence-based teaching: Tools and techniques that promote learning in the psychology classroom. *Australian Journal of Psychology, 65,* 5–13. doi:10.1111/ajpy.12004

Dündar, S. & Gündüz, N. (2016). Misconceptions regarding the brain: The neuromyths of pre-service teachers. *Mind, Brain, and Education, 10,* 212–232. doi:10.1111/mbe.12119

Funder, D. C. & Ozer, D. J. (2019). Evaluating effect size in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science, 2*, 156–168. doi:10.1177/2515245919847202

Furnham, A. & Hughes, D. J. (2014). Myths and misconceptions in popular psychology: Comparing psychology students and the general public. *Teaching of Psychology, 41*, 256–261. doi:10.1177/0098628314537984

Gardner, R. M. & Dalsing, S. (1986). Misconceptions about psychology among college students. *Teaching of Psychology, 13*, 32–34. doi:10.1207/s15328023top1301_9

Gaze, C. M. (2014). Popular psychological myths: A comparison of students' beliefs across the psychology major. *Journal of the Scholarship of Teaching and Learning, 14*, 46–60. doi:10.14434/josotl.v14i2.3931

Ghanizadeh, A., Bahredar, M. J. & Moeini, S. R. (2006). Knowledge and attitudes towards attention deficit hyperactivity disorder among elementary school teachers. *Patient Education and Counseling, 63*, 84–88. doi:10.1016/j.pec.2005.09.002

Gilovich, T. (1991). *How we know what isn't so: The fallibility of human reason in everyday life*. New York: Free Press.

Gitlin, A., Barlow, L., Burbank, M. D., Kauchak, D. & Stevens, T. (1999). Pre-service teachers' thinking on research: Implications for inquiry oriented teacher education. *Teaching and Teacher Education, 15*, 753–769. doi:10.1016/S0742-051X(99)00015-3

Hamza, K. M. & Wickman, P.-O. (2008). Describing and analyzing learning in action: An empirical study of the importance of misconceptions in learning science. *Science Education, 92*, 141–164. doi:10.1002/sce.20233

Hargreaves, D. H. (2000). Teaching as a research-based profession: Possibilities and prospects. In B. Moon, J. Butcher & E. Bird (Eds.), *Leading professional development in education* (pp. 200–210). London: RoutledgeFalmer.

Hermida, M. J., Segretin, M. S., Soni García, A. & Lipina, S. J. (2016). Conceptions and misconceptions about neuroscience in preschool teachers: A study from Argentina. *Educational Research, 58*, 457–472. doi:10.1080/00131881.2016.1238585

Higbee, K. L. & Clay, S. L. (1998). College students' beliefs in the ten-percent myth. *Journal of Psychology: Interdisciplinary and Applied, 132*, 469–476. doi:10.1080/00223989809599280

Howard-Jones, P., Franey, L., Mashmoushi, R. & Liao, Y.-C. (2009). *The neuroscience literacy of trainee teachers*. Paper presented at British Educational Research Association Annual Conference, Manchester.

Hughes, S., Lyddy, F., Kaplan, R., Nichols, A. L., Miller, H., Saad, C. G. et al. (2015). Highly prevalent but not always persistent: Undergraduate and graduate student's misconceptions about psychology. *Teaching of Psychology, 42*, 34–42. doi:10.1177/0098628314562677

Hughes, S., Lyddy, F. & Lambe, S. (2013). Misconceptions about psychological science: A review. *Psychology Learning & Teaching, 12*, 20–31. doi:10.2304/plat.2013.12.1.20

Ingram, D., Louis, K. & Schroeder, R. G. (2004). Accountability policies and teacher decision making: Barriers to the use of data to improve practice. *Teachers College Record, 106*, 1258–1287. doi:10.1111/j.1467-9620.2004.00379.x

Kendeou, P. & van den Broek, P. (2005). The effects of readers' misconceptions on comprehension of scientific text. *Journal of Educational Psychology, 97*, 235–245. doi:10.1037/0022-0663.97.2.235

KMK [Kultusministerkonferenz] (2004). *Standards für die Lehrerbildung: Bildungswissenschaften. Beschluss der Kultusministerkonferenz.* [*Standards for teacher education. Decision of the Conference of the Ministers of Education and Cultural Affairs.*] Bonn: KMK.

Kowalski, P. & Taylor, A. (2009). The effect of refuting misconceptions in the introductory psychology class. *Teaching of Psychology, 36,* 153–159. doi:10.1080/00986280902959986

Landau, J. D. & Bavaria, A. J. (2003). Does deliberate source monitoring reduce students' misconceptions about psychology? *Teaching of Psychology, 30,* 311–314.

Lassonde, K. A., Kolquist, M. & Vergin, M. (2017). Revising psychology misconceptions by integrating a refutation-style text framework into poster presentations. *Teaching of Psychology, 44,* 255–262. doi:10.1177/0098628317712754

Lilienfeld, S. O. (2005). Challenging mind myths in introductory psychology courses. *Psychology Teacher Network, 15*(3), 1–6.

Lilienfeld, S. O., Ammirati, R. & David, M. (2012). Distinguishing science from pseudoscience in school psychology: Science and scientific thinking as safeguards against human error. *Journal of School Psychology, 50*(1), 7–36. doi:10.1016/j.jsp.2011.09.006

Lilienfeld, S. O., Lynn, S., Ruscio, J. & Beyerstein, B. (2010). *50 great myths of popular psychology*. Oxford, England: Wiley-Blackwell.

Marsh, E. J., Cantor, A. D. & Brashier, N. M. (2016). Believing that humans swallow spiders in their sleep: False beliefs as side effects of the processes that support accurate knowledge. *Psychology of Learning and Motivation, 64,* 93–132. doi:10.1016/bs.plm.2015.09.003

Mason, L., Baldi, R., Di Ronco, S., Scrimin, S., Danielson, R. W. & Sinatra, G. M. (2017). Textual and graphical refutations: Effects on conceptual change learning. *Contemporary Educational Psychology, 49*, 275–288. doi:10.1016/j.cedpsych.2017.03.007

McCutcheon, L. E. (1991). A new test of misconceptions about psychology. *Psychological Reports, 68*, 647–653. doi:10.2466/pr0.1991.68.2.647

Menz, C., Spinath, B. & Seifried, E. (2020). Misconceptions die hard: Prevalence and reduction of wrong beliefs in topics from educational psychology among preservice teachers. *European Journal of Psychology of Education*. Advanced online publication. doi:10.1007/s10212-020-00474-5

Munro, G. D. (2010). The scientific impotence excuse: Discounting belief-threatening scientific abstracts. *Journal of Applied Social Psychology, 40*, 579–600. doi:10.1111/j.1559-1816.2010.00588.x

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*, 89–96. doi:10.1111/j.1751-228X.2012.01141.x

Pieschl, S., Archer, J. & Budd, J. (2019). *Raising student teachers' awareness of misconception regarding educational psychology*. Poster presented at the 2019 Annual Meeting of the American Educational Research Association (AERA), Toronto, Canada.

Prinz, A., Golke, S. & Wittwer, J. (2018). The double curse of misconceptions: Misconceptions impair not only text comprehension but also metacomprehension in the domain of statistics. *Instructional Science, 46*, 723–765. doi:10.1007/s11251-018-9452-6

Prinz, A., Golke, S. & Wittwer, J. (2019). Refutation texts compensate for detrimental effects of misconceptions on comprehension and metacomprehension accuracy and support transfer. *Journal of Educational Psychology, 111*, 957–981. doi:10.1037/edu0000329

Richter, T., Schroeder, S. & Wöhrmann, B. (2009). You don't have to believe everything you read: Background knowledge permits fast and efficient validation of information. *Journal of Personality and Social Psychology, 96*, 538–558. doi:10.1037/a0014038

Richter, T. & Singer, M. (2017). Discourse updating: Acquiring and revising knowledge through discourse. In M. F. Schober, D. N. Rapp & M. A. Britt (Eds.), *The Routledge handbook of discourse processes* (pp. 167–190). New York: Routledge. doi:10.4324/9781315687384-11

Schildkamp, K. & Kuiper, W. (2010). Data-informed curriculum reform: Which data, what purposes, and promoting and hindering factors. *Teaching and Teacher Education, 26*, 482–496. doi:10.1016/j.tate.2009.06.007

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*, 15–21. doi:10.3102/0013189X031007015

Slavin, R. E. (2008). Perspectives on evidence-based research in education – what works? Issues in synthesizing educational program evaluations. *Educational Researcher, 37*, 5–14. doi:10.3102/0013189X08314117

Taylor, A. K. & Kowalski, P. (2004). Naive psychological science: The prevalence, strength, and sources of misconceptions. *Psychological Record, 54*, 15–25. doi:10.1007/BF03395459

Tippett, C. D. (2010). Refutational text in science education: A review of two decades of research. *International Journal of Science and Mathematics Education, 8*, 951–970. doi:10.1007/s10763-010-9203-x

Vanderlinde, R. & van Braak, J. (2010). The gap between educational research and practice: Views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*, 299–316. doi:10.1080/01411920902919257

van Schaik, P., Volman, M., Admiraal, W. & Schenke, W. (2018). Barriers and conditions for teachers' utilisation of academic knowledge. *International Journal of Educational Research, 90,* 50–63. doi:10.1016/j.ijer.2018.05.003

Vaughan, E. D. (1977). Misconceptions about psychology among introductory psychology students. *Teaching of Psychology, 4,* 138–141. doi:10.1207/s15328023top0403_9

Appendices

Appendix A: English Translation of the Educational Psychological Statements

Mostly, mathematical and linguistic aptitude go hand in hand. (c)
Brain training enhances people's intelligence.
Grade retention does not have a positive influence on poor students' performance. (c)
Single-sex education and mixed-sex education lead to comparable learning outcomes. (c)
We only use 10% of our brain.
Highly gifted children have more social problems than children with normal intelligence.
Especially highly engaged teachers will suffer from burnout.
From international student assessments such as PISA, it is possible to derive concrete consequences for improving teaching.
The learning pyramid ("you learn 10% of what you read, 20% of what you hear, and 30% of what you see, …") is considered to have been disproved. (c)
ADHD cannot be attributed to poor parenting only. (c)
The new media makes us fat, stupid, and violent.
Boys are generally better at mathematics than girls.
Multitasking enables people to achieve more in less time without any negative influence on the results.
Intelligence is strongly inherited and therefore cannot be enhanced.

Note. (c) indicates statements formulated in accordance with the current state of research.

Tables

Table 1. Frequencies (Percentages) and Descriptive Statistics for Misconception Endorsement

Topic	Not at all	Rather not	Neither/nor	Rather	Very much	Misconception	*M*	*SD*
Mathematical and linguistic aptitude (c)	3 (0.4)	66 (7.9)	166 (19.9)	393 (47.0)	208 (24.9)	71.9%	3.88	0.89
Brain training	43 (5.1)	135 (16.1)	183 (21.9)	369 (44.1)	106 (12.7)	56.8%	3.43	1.06
Grade retention (c)	55 (6.6)	147 (17.6)	199 (23.8)	305 (36.5)	130 (15.6)	52.1%	3.37	1.14
Single-sex education (c)	61 (7.3)	193 (23.1)	211 (25.2)	282 (33.7)	89 (10.6)	44.3%	3.17	1.12
Use of the brain	117 (14.0)	148 (17.7)	209 (25.0)	265 (31.7)	97 (11.6)	43.3%	3.09	1.23
Highly gifted people	73 (8.7)	143 (17.1)	302 (36.1)	267 (31.9)	51 (6.1)	38.0%	3.10	1.04
Burnout	100 (12.0)	217 (26.0)	217 (26.0)	242 (28.9)	60 (7.2)	36.1%	2.93	1.15
International student assessments	111 (13.3)	293 (35.0)	176 (21.1)	231 (27.6)	25 (3.0)	30.6%	2.72	1.10
Learning pyramid (c)	90 (10.8)	217 (26.0)	329 (39.4)	177 (21.2)	23 (2.8)	24.0%	2.79	0.99
ADHD (c)	245 (29.3)	264 (31.6)	138 (16.5)	119 (14.2)	70 (8.4)	22.6%	2.41	1.27
New media	234 (28.0)	266 (31.8)	178 (21.3)	139 (16.6)	19 (2.3)	18.9%	2.33	1.12
Gender differences in mathematics	297 (35.5)	224 (26.8)	178 (21.3)	116 (13.9)	21 (2.5)	16.4%	2.21	1.14
Multitasking	228 (27.3)	366 (43.8)	163 (19.5)	67 (8.0)	12 (1.4)	9.4%	2.13	0.95
Intelligence	263 (31.5)	368 (44.0)	127 (15.2)	67 (8.0)	11 (1.3)	9.3%	2.04	0.95

Note. $N = 836$; (c) indicates items formulated in accordance with the current state of research; for each topic, high values for *rather* and *very much* indicate a misconception (i.e., correct statements have been recoded); an English translation of the items' wording is presented in Appendix A.

Table 2. Average Percentages of Points Distributed Across the Sources of Beliefs and Misconceptions About Educational Psychological Topics

	Common sense	Lectures	Media	Narratives from other people	Personal experience	Scientific research	Other/I can't name the source	Aggregated: Anecdotal evidence	Aggregated: Scientific evidence
Beliefs [a]	17.04	18.94	10.67	10.76	21.93	8.26	12.40	32.69	27.20
Misconceptions [b]	16.93	19.30	10.58	12.39	23.56	7.85	9.39	35.95	27.15

Note. [a] $n = 836$. [b] $n = 833$; *aggregated: anecdotal evidence* includes narratives from other people and personal experience; *aggregated: scientific evidence* includes lectures and scientific research.

Table 3. Percentages of Points Distributed Across Each Source for Each Topic

Topic	Common sense	Lectures	Media	Narratives from other people	Personal experience	Scientific Research	Other/I can't name the source	Aggregated: Anecdotal evidence	Aggregated: Scientific evidence
Mathematical and linguistic aptitude (c)	15.01	16.49	5.46	11.28	34.01	6.70	11.04	45.83	23.19
Brain training	21.50	17.48	11.82	9.15	22.13	8.03	9.89	31.28	25.51
Grade retention (c)	12.56	19.34	6.10	20.55	23.33	6.70	11.42	43.88	26.04
Single-sex education (c)	14.47	18.54	8.34	10.33	18.02	7.95	22.29	28.35	26.49
Use of the brain	28.49	13.98	19.04	4.31	4.43	11.60	18.16	8.74	25.58
Highly gifted people	13.96	17.86	13.16	15.69	21.67	6.58	11.08	37.36	24.44
Burnout	13.28	17.84	13.54	21.00	14.89	4.47	15.00	35.89	22.31
International student assessments	11.44	38.54	12.90	6.68	11.02	7.26	6.78	17.70	45.80
Learning pyramid (c)	13.90	17.30	5.44	6.30	22.91	6.62	27.53	29.21	23.92
ADHD (c)	19.98	20.61	9.43	12.62	18.10	10.37	8.89	30.72	30.98
New media	20.06	9.49	20.51	8.03	27.45	7.12	7.34	35.48	16.61
Gender differences in mathematics	15.75	19.22	8.73	9.33	30.84	9.73	6.34	40.17	28.95
Multitasking	17.98	10.29	7.20	9.33	41.75	4.96	8.49	51.08	15.25
Intelligence	20.24	28.21	7.64	6.00	16.41	12.24	9.27	22.41	40.45

Note. $N = 836$; *aggregated: anecdotal evidence* includes narratives from other people and personal experience; *aggregated: scientific evidence* includes lectures and scientific research.

Paper 3

This is the accepted version of the article

Menz, Cordelia, Spinath, Birgit, Hendriks, Friederike, & Seifried, Eva (in press). Reducing Educational Psychological Misconceptions: How Effective Are Standard Lectures, Refutation Lectures, and Instruction in Information Evaluation Strategies? *Scholarship of Teaching and Learning in Psychology*.

Reducing Educational Psychological Misconceptions: How Effective are Standard Lectures, Refutation Lectures, and Instruction in Information Evaluation Strategies?

(12.684 words)

Cordelia Menz[1*], Birgit Spinath[1], Friederike Hendriks[2], & Eva Seifried[1]

[*]corresponding author; Correspondence concerning this article should be addressed to Cordelia Menz, Department of Psychology, Heidelberg University, Hauptstr. 47-51, 69115 Heidelberg, Germany. E-mail: Cordelia.Menz@psychologie.uni-heidelberg.de

[1]Heidelberg University, Germany; [2]University of Münster, Germany

Funding. This research project was financially supported by the Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (Az: 33-7533.-30-10/25/63) and by the Excellence Initiative of the German Federal Government and the state governments – Funding line Institutional Strategy (Zukunftskonzept): DFG project number ZUK 49/Ü ("Heidelberg: Realising the Potential of a Comprehensive University").

Acknowledgment. The authors want to thank Dr. Anne Weidinger, the instructor of the standard lecture, for her support of our study.

Reducing Educational Psychological Misconceptions: How Effective are Standard Lectures, Refutation Lectures, and Instruction in Information Evaluation Strategies?

Abstract (240 words)

Psychological misconceptions can be a threat for reaching educational goals and should consequently be prevented. In this study, we analyzed different methods to combat psychological misconceptions: We contrasted a standard lecture with a refutation lecture, and tested the effects of a short intervention educating about cognitive biases and imparting strategies to evaluate information analytically. Prevalence of and reduction in 18 educational psychological misconceptions as well as enhancement of metacognitive monitoring accuracy regarding these misconceptions were analyzed among $N = 266$ German preservice teachers who participated in online surveys at the beginning and the end of one semester. Results indicated a high prevalence of diverse misconceptions (11 misconceptions were endorsed by more than 50% of preservice teachers at t1). The refutation lecture led to a strong reduction in refuted misconceptions, with an unexpected spill-over effect on misconceptions that were not addressed. The standard lecture resulted in a smaller reduction in the targeted misconceptions only, whereas imparting information evaluation strategies showed no effects on misconception reduction. For metacognitive monitoring accuracy, we found analogous results. Based on these results and a follow-up survey half a year later, we conclude that educational psychological misconceptions are widespread among preservice teachers and that refutations in psychology lectures are an effective approach to counteract specific misconceptions with enduring effects. Thus, our results—which could be replicated with other psychological misconceptions and student populations—have implications for both psychology researchers and instructors who aim to reduce psychological misconceptions.

Keywords: Cognitive Biases; Educational Psychology; Misconceptions; Preservice Teachers; Refutation Lectures

A prototypical teacher probably believes in the effectiveness of learning styles, namely, that students learn better when study materials match their preferred learning style (e.g., visual, auditory, or kinesthetic) (see Howard-Jones, 2014). This erroneous belief is widespread among teachers and preservice teachers in many nations, even though there is ample empirical evidence against it (see e.g., Pashler et al., 2008; Willingham et al., 2015). Now imagine teachers who put their belief into action by investing a lot of time to assess students' preferred learning style as well as to invent different materials for different possible learning styles. In this case, while teachers present information in diverse modes—which might in fact help students learn—they are doing the right thing for the wrong reason. Instead, it would be worthwhile to focus on the right thing for the right reason, that is, to spend one's time and energy on evidence-based practices and theories (see Newton, 2015; Pashler et al., 2008; Willingham et al., 2015). Teachers' beliefs in learning styles could lead them to hold limited expectations about how and how well their students can learn, probably impeding students' learning outcomes, for example, by not encouraging a child to try otherwise. Aside from that, through the teachers' focus on learning styles in the classroom, they also introduce the idea of effective learning styles to their students who might in turn spread the idea further to their parents or peers. In addition, a focus on learning styles in the classroom could lead students to believe they can only learn in one way and that this ability to learn is fixed and unchangeable. Taken together, the learning styles misconception holds dangers for teachers and students alike, and this is only one example of a particular misconception that illustrates why teachers should be prevented from endorsing psychological misconceptions—at best at an early stage in their careers when they are confronted with scientific evidence (i.e., during teacher education). Refutations[1] have been shown to be an effective approach for reducing specifically targeted misconceptions (e.g.,

[1] Refutations activate prior knowledge, explicitly hint to the inaccuracy of this prior knowledge, and present correct information and explanations why the prior knowledge is incorrect (see Reducing Misconceptions Directly: Refutations section). In the literature, different terms for refutations have been used (i.e., refutation texts, refutational texts, refutation-style texts, refutational lectures). Throughout this article, we constantly refer to the terms 'refutation texts' and 'refutation lectures'.

Kendeou et al., 2019; Prinz et al., 2019; Taylor & Kowalski, 2014). Conversely, finding a way to reduce misconceptions unspecifically (i.e., not specifically targeting single misconceptions) and permanently could be a valuable approach to prevent and combat misconceptions. Maybe, it is possible to combat misconceptions indirectly by educating about cognitive biases and imparting strategies to evaluate information analytically, because cognitive biases can form or encourage misconceptions (e.g., Blanchett Sarrasin et al., 2019; Gilovich, 1991; Lazer et al., 2018; Pasquinelli, 2012).

The aim of this study was to investigate different methods to combat psychological misconceptions. We analyzed the prevalence of a variety of educational psychological misconceptions among German preservice teachers with a confidence-sensitive measurement. We compared the effects that lecture programs with either a standard approach (i.e., standard lecture) or refutations (i.e., refutation lecture) have on reducing misconceptions, and additionally investigated an intervention that educates about cognitive biases and imparts strategies to evaluate information analytically (i.e., information evaluation strategies). We further investigated the effects of these methods on preservice teachers' metacognitive monitoring accuracy. In addition, we analyzed whether the different methods show enduring effects regarding the reduction in misconceptions and the enhancement of metacognitive monitoring accuracy by assessing the same half a year after the post-test.

Psychological Misconceptions in the Context of Education

In general, misconceptions can be defined as "inaccurate prior knowledge" (Taylor & Kowalski, 2014, p. 259). More specifically, psychological misconceptions can be defined as "commonsense beliefs about the mind, brain, and behavior that are held contrary to what is known from psychological research" (Bensley & Lilienfeld, 2015, p. 289), thus, beliefs that are not in line with the current state of knowledge (although the latter, of course, might change over time). Psychological misconceptions have been studied in psychology students for decades

(e.g., Bensley & Lilienfeld, 2015; Gregg et al., 2001; Hughes et al., 2015; McCutcheon et al., 1992; Taylor & Kowalski, 2004; Vaughan, 1977). Some of these studies investigated how psychology students enter and leave psychology classes regarding their inaccurate knowledge (e.g., Gregg et al., 2001; Kowalski & Taylor, 2004; Vaughan, 1977). However, psychological knowledge can be useful in many occupations, and hence, not only students who want to major in psychology but also many other students take psychology classes. This makes dealing effectively with misconceptions in these lower level classes particularly pressing because they probably constitute the only opportunity to rebut psychological misconceptions with scientific findings during academic education. This is the case, for example, for preservice teachers, for whom acquiring psychological knowledge throughout their studies is particularly important to become educational experts. Educational psychology as a specific psychology subfield concentrates on questions that directly address aspects of teaching and learning, which are relevant to the future practice of preservice teachers. This is why basic psychology courses are included in teacher education programs in many countries (see e.g., Dutke et al., 2016; Patrick et al., 2011). Therefore, investigating educational psychological misconceptions (i.e., misconceptions that comprise psychological topics in the context of education, see Menz et al., 2020) in preservice teachers—and how these future educational experts enter and leave educational psychology classes—is an important area of research within psychology education.

So far, misconception research with teachers and preservice teachers has mainly focused on neuroscientific topics (e.g., Dekker et al., 2012; Grospietsch & Mayer, 2018; Howard-Jones, 2014; Macdonald et al., 2017; Ruhaak & Cook, 2018). Therefore, most of our knowledge regarding teachers' and preservice teachers' misconceptions about learning styles stems from research about neuroscientific misconceptions. The corresponding studies showed that false beliefs about the effectiveness of different learning styles were widespread (e.g., Dekker et al., 2012; Dündar & Gündüz, 2016; Ferrero et al., 2016; Gleichgerrcht et al., 2015; Howard-Jones, 2014; Lethaby & Harries, 2016; Menz et al., 2020; Pei et al., 2015; Tardif et al., 2015). Recent

studies found that other and more general educational psychological misconceptions were also prevalent among preservice teachers (e.g., Menz et al., 2020, 2021; Pieschl et al., 2019). However, teachers are expected to use scientific evidence and academic research for planning and organizing their teaching processes (see standards for teacher education, e.g., Commission of the European Communities, 2007; Kultusministerkonferenz, 2004). To achieve this evidence-based practice, it is essential to identify misconceptions that might influence teachers' actions (Pashler et al., 2008) because if teachers concentrate on ideas that have not proven effective by scientific research, this could harm education, directly or indirectly (see Pasquinelli, 2012). Thus, educational psychological misconceptions should be prevented or combatted in the process of teachers' scientific education.

To ascertain the status quo and to have a baseline for our main investigations, with our first research question (RQ1), we investigated the prevalence of diverse educational psychological misconceptions among German preservice teachers.

Reducing Misconceptions

Psychological misconceptions have been found to not only be highly prevalent but also to be very persistent (see e.g., Bensley et al., 2015; Hughes et al., 2015), and resistant to enduring change (see Taylor & Kowalski, 2014). Several early studies have shown that students' psychological misconceptions do not change a lot after taking introductory psychology classes (e.g., Gardner & Dalsing, 1986; Vaughan, 1977), however, there are also studies indicating the opposite (e.g., Kowalski & Taylor, 2009). Thus, gathering new knowledge in university courses can at least sometimes help to combat misconceptions. Nevertheless, because standard teaching does not seem to contribute efficiently and permanently to change students' psychological misconceptions, different approaches to directly reduce misconceptions have been investigated (e.g., Kowalski & Taylor, 2009; Lassonde et al., 2016, 2017; Taylor & Kowalski, 2014).

Reducing Misconceptions Directly: Refutations

One technique to directly reduce misconceptions that has achieved extensive attention is an approach referred to as 'refutations'. Refutations can either be applied through texts (see e.g., Kendeou et al., 2014, 2019; Lassonde et al., 2016, 2017; Menz et al., 2020; Prinz et al., 2019) or lectures (see e.g., Kowalski & Taylor, 2009; Taylor & Kowalski, 2014). Refutation texts and lectures are used to induce cognitive conflict (see e.g., Guzzetti, 2000) and to acquire conceptual change (see e.g., Kowalski & Taylor, 2009; Tippett, 2010). Refutations activate prior knowledge (i.e., the misconception in question), explicitly state that this prior knowledge is inaccurate, and present correct information and explanations why the prior belief is incorrect (see Lassonde et al., 2017). This can help to decrease the influence of the incorrect prior knowledge and increase the influence of the accurate new information (see Kendeou et al., 2014). Recently, it has been argued that inoculations, that is, including a kernel of truth and why people believe in the misconception, might support the effects of refutations (see Taylor & Kowalski, 2019).

Previous studies have shown that refutation texts are effective at reducing misconceptions from different areas and among different age groups (e.g., Diakidoy et al., 2003; Lassonde et al., 2016; van Loon et al., 2015), and so have refutation *lectures* in introductory psychology classes (e.g., Kowalski & Taylor, 2009; Taylor & Kowalski, 2014). Kowalski and Taylor (2009) compared refutation lectures (i.e., activating the misconception and refuting it with scientific evidence) with standard lectures (i.e., only presenting scientific evidence without activating the misconception) in introductory psychology classes. Results showed that refutation lectures accompanied by refutation texts were more effective at reducing psychological misconceptions than standard lectures combined with standard texts. Furthermore, while many attempts to reduce misconceptions investigated short-term changes (e.g., Kowalski & Taylor, 2004; Lassonde et al., 2016), less is known about their long-term

effects (for an exception, see Kowalski & Taylor, 2017). Taken together, previous research indicates that refutations are effective at reducing misconceptions that are directly targeted. However, a specific refutation is assumed to only work for a specific misconception because it merely induces conceptual change for the targeted topic (see Kowalski & Taylor, 2009; Taylor & Kowalski, 2019; Tippett, 2010). Reasons for the specificity of refutations could be grounded in the different nature of each single misconception (Tippett, 2010, see also Menz et al., 2021) or in the absence of an overarching conceptual framework that might be addressed to combat all possible misconceptions (see Taylor & Kowalski, 2019). In other words, refutations for one topic are said to have no overarching effect on other, non-targeted misconceptions (see Taylor & Kowalski, 2019).

Reducing Misconceptions Indirectly: Information Evaluation Strategies

Because refutations are said to only work for one specific misconception at a time, Taylor and Kowalski (2014) suggested exploring other methods that make students evaluate their knowledge and prior beliefs to reduce misconceptions. Especially in times of a post-truth world (see e.g., Barzilai & Chinn, 2020), people rely on their intuitions and emotions instead of facts—and thus, fall prey to cognitive biases (Horsthemke, 2017). In general, people tend to evaluate the truth of information intuitively instead of analytically (Schwarz et al., 2016), with cognitive biases impairing people's judgments (see Kahneman et al., 1982). Thus, it is not surprising that cognitive biases have been argued to also play an important role regarding the formation and endorsement of misconceptions (e.g., Howard-Jones, 2014; Pasquinelli, 2012). Theoretically, misconceptions can arise from a variety of different cognitive biases, for example, confirmation bias, desirability bias, or illusory correlations (see e.g., Gilovich, 1991; Lazer et al., 2018; Pasquinelli, 2012). Empirically, Blanchett Sarrasin et al. (2019) showed that cognitive biases were the main source of various neuroscientific misconceptions among teachers. Thus, educating about different cognitive biases could be a first step to prevent them

from endorsing misconceptions (see Lee, 2017). However, Beaulac and Kenyon (2014) argue that in addition to gaining knowledge about cognitive biases, it is also necessary to help people leave the path of their usual habits and to equip them with skills against biased thinking. In the same line, Maynes (2015) states that acquiring specific debiasing strategies regarding how to deal with biased thinking is essential. Further, not practicing and not knowing when to apply these newly adopted strategies might be an additional obstacle for reaching effective debiasing (e.g., Aczel et al., 2015; Maynes, 2015). Therefore, people not only need to be educated about their usual habits when evaluating information and how to do it better (i.e., analytically instead of intuitively; see Schwarz et al., 2016) but also need to be equipped with tools that help them to apply their new knowledge (see Beaulac & Kenyon, 2014). A change in thinking can be achieved when people are made aware of situations in which they should apply their newly acquired knowledge (see Aczel et al., 2015) and then have something at hand to do this properly (e.g., by using a checklist; Maynes, 2015; O'Sullivan & Schofield, 2018). Thus, we ask whether a combination of these aspects (i.e., education about cognitive biases, strategies to overcome these biases, checklists when and how to apply these strategies; information evaluation strategies) can have an effect on the endorsement of various misconceptions.

In sum, while some studies found that psychological misconceptions decreased after standard lectures in psychology (e.g., Kowalski & Taylor, 2004), other studies have shown no effect (e.g., Gardner & Dalsing, 1986; Vaughan, 1977). Furthermore, many studies indicate that refutation lectures are far more effective at reducing psychological misconceptions than standard lectures (e.g., Kowalski & Taylor, 2009; Taylor & Kowalski, 2014). Nevertheless, one disadvantage of refutations is their specificity; refutations are said to work for targeted misconceptions only (see Taylor & Kowalski, 2019). However, because misconceptions can arise from cognitive biases (see e.g., Lazer et al., 2018; Pasquinelli, 2012), teaching students about cognitive biases, how to deal with them, and how to evaluate information analytically instead of intuitively (Maynes, 2015; O'Sullivan & Schofield, 2018; Schwarz et al., 2016) could

have an effect on the endorsement of psychological misconceptions in general. We therefore formulated the following hypothesis (H1) and research question (RQ2) regarding the reduction in psychological misconceptions:

H1: Standard lectures and refutation lectures have a reducing effect on the endorsement of addressed psychological misconceptions; this effect is stronger for refutation lectures.

RQ2: Does teaching information evaluation strategies have a reducing effect on psychological misconceptions?

In addition, because many attempts to reduce misconceptions only investigated short-term changes (e.g., Kowalski & Taylor, 2004; Lassonde et al., 2016; Menz et al., 2020) and less is known about their long-term effects, we included a follow-up survey half a year after the post-test to investigate whether the effects of the three approaches are enduring.

Measurement of Misconceptions and its Critique

In the psychological misconception literature, there is a broad range of instruments to measure misconceptions. Since early studies about misconceptions, true-false formats have been a popular way of measurement, where participants are confronted with a—mostly false—statement and asked to indicate whether the statement is true or false (e.g., Kuhle et al., 2009; McKeachie, 1960; Vaughan, 1977). These formats have been criticized for different reasons, for example, to force participants to give an answer because there is no ‘I do not know’ category, or to ignore response styles (see Bensley et al., 2014; Bensley & Lilienfeld, 2015; Hughes et al., 2013). As a result, some researchers used another format, namely, contrasting two statements—one representing correct knowledge and the other representing a misconception—and forcing participants to select the better alternative (e.g., Bensley et al., 2014; Pieschl et al., 2019). Using multiple-choice questionnaires (e.g., McCutcheon, 1991) also offers the chance to pose the correct answer against common other answers that can represent misconceptions.

However, finding plausible equivalent alternatives to a statement in question can be challenging (e.g., what is the opposite of ‘increased achievement’: ‘decreased achievement’ or ‘no effect’?) and thus, determines the success of this kind of measurement. Another way to extend classical true-false formats is using confidence ratings (e.g., Hughes et al., 2015; Menz et al., 2020; Taylor & Kowalski, 2004). Confidence ratings can be used either in the form of point-scales to indicate how much someone agrees with a statement (e.g., Hughes et al., 2015; Menz et al., 2020) or in the form of an additional rating to true-false formats or other measurements (e.g., Bensley et al., 2014; Gaze, 2014; Taylor & Kowalski, 2004). An advantage of confidence ratings—apart from an unambiguous phrasing (vs. when using contrary statements or multiple-choice questionnaires)—is the possibility to indicate guessing. For example, Taylor and Kowalski (2004) extended their true-false format by a ten-point confidence scale and defined a confidence of below five as guessing. In addition, repeatedly used confidence ratings might also help to identify misconceptions that are in the process of change, that is, misconceptions that are not rejected, yet asserted with decreased confidence (see Hughes et al., 2013). At single measurement occasions, confidence ratings provide an opportunity to gain insights into participants’ metacognition (see e.g., Barenberg & Dutke, 2013, see also next section), that is, to analyze not only whether a false statement is rejected but also whether this is done with low or high confidence. Such insights into what someone knows or does not know are essential for teachers to prevent them from transmitting inaccurate knowledge.

Thus, we chose to implement the format used by Taylor and Kowalski (2004) for the present study, making it possible to calculate an index for students’ metacognitive monitoring accuracy (i.e., the bias index defined by Schraw, 2009a). Moreover, we also used positively formulated statements to counteract response biases, which constitutes a common critique of true-false formats (see Bensley & Lilienfeld, 2015).

Metacognitive Monitoring Accuracy

Self-regulated learning is crucial for successful learning in higher education as well as for life-long learning (see e.g., Kurbanoglu, 2003; Roth et al., 2016; Van Eekelen et al., 2005), and metacognition plays an important role in self-regulated learning (e.g., Boekaerts, 1999). Metacognition can be defined as "knowledge and cognition about cognitive phenomena" (Flavell, 1979, p. 906), thus, including awareness about what someone knows or does not know. One aspect of metacognition is metacognitive monitoring, which describes the association between someone's learning (i.e., performance) and someone's perception of the learning outcome (i.e., confidence) (see Barenberg & Dutke, 2013). Both an increase of knowledge as well as an increase of confidence in that knowledge should be acquired in higher education (see Dutke & Barenberg, 2009). The accuracy of metacognitive monitoring can be assessed by the discrepancy between one's knowledge (i.e., performance) and one's confidence in that knowledge (see Barenberg & Dutke, 2013). To prevent teachers from transmitting inaccurate knowledge, it is particularly important for them to acquire a high metacognitive monitoring accuracy, that is, to know what they know and what they do not know.

There is initial evidence that standard psychology lectures can foster both students' gain in knowledge and students' gain in confidence regarding their acquired knowledge (Dutke & Barenberg, 2009). Because refutation lectures can be classified as standard lectures that additionally induce cognitive conflict for specific topics (see e.g., Guzzetti, 2000), refutation lectures should also—or even better—support students to become aware of what they know or do not know. However, metacognitive judgments can be negatively influenced by cognitive biases, and informing people about this influence has been argued to reduce it (e.g., Chew et al., 2016; see also Dunlosky & Metcalfe, 2009; Serra & Metcalfe, 2009). In other words, learning about cognitive biases and acquiring strategies how to diminish the influence of these biases on the evaluation of information could make students become aware about their thinking processes. Realising that one's knowledge may be influenced by various cognitive biases could therefore support students to reflect on what they know and what they do not know.

We therefore formulated the following hypothesis (H2) and research question (RQ3) regarding the enhancement of metacognitive monitoring accuracy:

H2: Standard lectures and refutation lectures have a positive effect on metacognitive monitoring accuracy, that is, they improve one's awareness about what someone knows or does not know; the improvement is stronger for the addressed topics than for the non-addressed topics.

RQ3: Does teaching information evaluation strategies have a positive effect on metacognitive monitoring accuracy?

Again, with our follow-up survey, we investigated whether the effects of the three approaches are enduring: For both the reduction in psychological misconceptions and the enhancement of metacognitive monitoring accuracy, we expected persistent effects, albeit smaller compared to the initial effects.

Method

Data Collection

For this study, the software *SoSci Survey* was used to implement online surveys at the beginning (pre-test) and at the end (post-test) of the academic summer term 2019, as well as at the end of the academic winter term 2019/2020 (follow-up invitation at least half a year after post-test invitation). Part of the data presented in this study (i.e., data from the standard- and the refutation-group) was assessed in a larger research project focusing primarily on the development of different variables through educational psychology lecture programs during one semester (for all variables, see Hendriks et al., 2021). More precisely, we looked at two subgroups of this research project, namely, those that were recruited from two specific educational psychology lecture programs that covered certain misconceptions either in the form of a standard lecture (at TU Dortmund University; forming the standard-group) or in the form

of a refutation lecture (at Heidelberg University; forming the refutation-group) (for a detailed description of the lecture programs, see Approaches of Intervention section). In addition to the group-specific requirements for the two lecture-groups to take the corresponding lecture (i.e., the standard or the refutation lecture), the only further requirement to participate in this study was enrollment in an academic and/or vocational teacher education program at a German university. Completing each questionnaire for participants in the standard- and the refutation-group took about 30 minutes. Another subgroup of the current study that was not part of the aforementioned research project, the information evaluation strategies-group, received their intervention as part of another online survey between the pre- and the post-test. This subgroup was recruited via social media platforms for preservice teachers at different universities. Completing each questionnaire for participants in the information evaluation strategies-group took about 15 minutes. No one received course credit for participating in this study; instead, we encouraged students to support psychological research and offered a monetary compensation. The compensation for participating in all surveys (apart from the follow-up survey) was lower for the information evaluation strategies-group (10€ compensation and lottery for 3 drawings of 20€ each) than for the standard- and refutation-group (20€ compensation and lottery for 3 drawings of 50€ each). For participating in the follow-up survey, all participants were offered an additional chance to enter a lottery for 30 drawings of 10€ each. At the beginning of each survey, participants were informed about the anonymous data collection and at the end, participants were asked about informed consent to use their data for research purposes.

Participants

We excluded nine participants because they did not give informed consent to use their data for research purposes at all measurement points; no other participants had to be excluded. Therefore, the final sample of this study included $N = 266$ preservice teachers. Of this sample, 72.9% were women, 26.7% were men, and one person reported to be inter/diverse. The age of

the participants ranged from 18 to 40 years (M = 21.79, SD = 3.03), and the preservice teachers had been studying at the university for between one and 28 semesters (M = 4.52, SD = 3.11). The standard-group consisted of n = 68 preservice teachers, the refutation-group consisted of n = 116 preservice teachers, and the information evaluation strategies-group consisted of n = 82 preservice teachers. About one third of each group participated in the follow-up investigation (i.e., n = 27 for the standard-group, n = 43 for the refutation-group, n = 39 for the information evaluation strategies-group). There were no missing data due to the settings of the surveys.

Materials and Measures

Endorsement of Educational Psychological Misconceptions

To address our research question regarding the prevalence of different misconceptions (RQ1), we chose 18 educational psychological topics that can be classified as important for preservice teachers' future careers. Most of the topics have recently been investigated (see de Bruyckere et al., 2015; Menz et al., 2020, 2021; Pieschl et al., 2019), but some were slightly adapted regarding their wording. We additionally chose three other topics because they are often misunderstood in our lecture programs. An English translation of the 18 statements is included in Appendix A. Six statements were formulated to be in accordance with the current state of research (i.e., true) and twelve statements were formulated to be contrary to the current state of research (i.e., false). The statements were presented in random order in all surveys. Participants read one statement about each topic and indicated whether the statement was true or false. In addition, they indicated their confidence in the assessment of the truth of the statement on a 10-point scale (1 = *not confident at all (guessing)*; 10 = *very confident*). In line with Taylor and Kowalski (2004), confidence ratings between 1 and 4 were classified as guessing and therefore not considered a misconception or a correct assessment, independent of the true-false rating. Thus, endorsing a misconception was defined as judging a false statement (i.e., a statement that is not in accordance with the current state of research) as true plus

indicating confidence in this judgment ≥ 5, or judging a true statement (i.e., a statement that is in accordance with the current state of research) as false plus indicating confidence in this judgment ≥ 5. To indicate the prevalence rates, we analyzed the endorsement of misconceptions assessed with the survey at the beginning of the summer term 2019.

Metacognitive Monitoring Accuracy

To analyze preservice teachers' metacognitive monitoring accuracy, we used the same 18 statements and calculated a measure of absolute accuracy for each statement. We used Schraw's (2009b) bias index, defined by the formula $1/n \sum_{i=1}^{n}(c_i - p_i)$ with c_i as confidence rating and p_i as performance rating. This bias index indicates the degree of under- and overconfidence of individuals who make performance and confidence judgments. The higher negative the bias index, the more underconfident, and the higher positive the bias index, the more overconfident a person is in their judgment. A bias index of 0 indicates the perfect match of performance and confidence (i.e., neither under- nor overconfidence).

Approaches of Intervention

To address our hypotheses and research questions regarding the reduction in psychological misconceptions (H1, RQ2) and the enhancement of metacognitive monitoring accuracy (H2, RQ3) through different approaches, we compared a standard lecture with a refutation lecture, and also investigated a group receiving information evaluation strategies. To indicate these changes, we analyzed the endorsement of misconceptions and the metacognitive monitoring accuracy assessed with the surveys at the beginning and at the end of the summer term 2019. To investigate the long-term effects of the approaches, we repeated the analyses including the data from the survey at the end of the winter term 2019/2020 (i.e., follow-up invitation at least half a year after post-test invitation).

Standard and Refutation Lectures. This study was conducted as a field study in two educational psychology lecture programs during one semester at different universities with differing course content. The standard lecture covered five and the refutation lecture covered nine of the 18 topics; thus, 13 or nine topics, respectively, were not covered in the lectures (i.e., non-targeted). Of the 18 topics, five were covered both in the standard lecture and the refutation lecture (see Appendix A). In the standard lecture, content was taught without explicitly refuting misconceptions, whereas in the refutation lecture, misconceptions were refuted following the same structure (see Taylor & Kowalski, 2019): First, the fact was explicitly stated, and then, the misconception was activated. Afterwards, evidence why wrong is wrong was presented, followed by evidence why right is right. The refutation always ended with an inoculation. In both the standard and the refutation lecture, the misconceptions were addressed in the specific lecture session covering the corresponding topic.

Information Evaluation Strategies. The information evaluation strategies were delivered online; participants of this subgroup first were informed about criteria (e.g., social consensus) that people generally use when they judge the truth of statements (see Schwarz et al., 2016). They were told that people generally tend to evaluate judgments intuitively, and were given examples for the questions that people ask themselves during such an intuitive evaluation (e.g., whether the information feels familiar; see Schwarz et al., 2016). In addition, participants were informed about different cognitive biases (e.g., the confirmation bias) that may impair judgments when evaluating intuitively, followed by a short definition of each bias. Because research on complex learning has found that providing students with examples of new concepts is more effective for learning than having students generate their own examples due to cognitive load (see e.g., Kirschner et al., 2006; van Marriënboer & Sweller, 2005), we chose to use a two-step process, including both aspects. After reading the definitions of twelve cognitive biases, the possible influence of these biases was exemplified using people's denial of human-caused climate change (e.g., confirmation bias: people who deny human-caused climate change only

search for and read information regarding this topic that displays their attitude regarding climate change). Because also generating answers yourself can be beneficial (see e.g., Bjork & Bjork, 2011), participants where then asked to come up with possible examples for the cognitive biases themselves: Participants were asked to generate examples of how the different cognitive biases might contribute to the emergence and persistence of the inaccurate belief that vaccinations harm children more than they help them. Afterwards, participants were informed about what kind of strategies someone can use to evaluate a statement analytically instead of intuitively, leading to the idea that these strategies are used in scientific research. In the end, participants were asked to apply these strategies when reading information online or in the news during the next weeks. To facilitate application, participants were provided with a checklist including helpful questions they could ask themselves when evaluating information.

Statistical Analyses

We used the program IBM SPSS Statistics (version 26) for all statistical analyses. To test H1 and H2 (as well as corresponding long-term effects) for the standard-group and the refutation-group, we computed mixed analyses of variances (ANOVAs); in addition, for H2, we also used one-sample *t*-tests. To test our RQ2 and RQ3 for the information evaluation strategies-group, we computed dependent-samples *t*-tests; again, for RQ3, we also used one-sample *t*-tests; to test long-term effects for the information evaluation strategies-group, we had planned a mixed ANOVA.

Results

In this section, the prevalence of the 18 investigated educational psychological misconceptions among our German preservice teachers' sample (RQ1) is presented first. Afterwards, analyses regarding the effects of the three approaches (i.e., standard lecture, refutation lecture, information evaluation strategies) on misconception endorsement are depicted (H1, RQ2), followed by their effects on metacognitive monitoring accuracy (H2,

RQ3). Then, possible long-term effects regarding both misconception endorsement and metacognitive monitoring accuracy are presented. For prevalence rates of misconception endorsement, see Table 1; for descriptive statistics regarding misconception endorsement and metacognitive monitoring accuracy for the three approaches, see Table 2; for the corresponding data of the follow-up, see Table 3.

Prevalence of Misconceptions (RQ1)

The prevalence rates of the 18 investigated educational psychological misconceptions ranged from 20.7% to 87.2% with prevalence rates above 50% for eleven topics (for all prevalence rates, see Table 1). The number of misconceptions endorsed by preservice teachers varied between 0 and 16 with endorsement of 10 misconceptions as the modal value. These prevalence rates indicate that the majority of preservice teachers holds misconceptions about many different educational psychological topics.

- Insert Table 1 around here -

- Insert Table 2 around here -

Reduction in Misconception Endorsement (H1, RQ2)

With regard to the first part of H1, we had a closer look at the effects of the two lecture programs. Because the addressed misconceptions partly differed between the lecture programs, we first investigated each lecture program separately. To test whether *standard lectures* had a reducing effect on targeted misconceptions, we computed a 2 (five targeted topics vs. 13 non-targeted topics) x 2 (t1 vs. t2) mixed ANOVA. There was no main effect of targeting, $F(1, 67) = 0.642$, $p = .426$, and no main effect of time, $F(1, 67) = 0.923$, $p = .340$, but a significant interaction effect, $F(1, 67) = 11.022$, $p = .001$, part. $\eta^2 = .141$. Simple effects analyses following up on the significant interaction indicated that at t1, preservice teachers had more misconceptions about topics that would be targeted in the lecture than about topics that would

not be targeted (p = .005, part. η^2 = .111) and that the targeted misconceptions were reduced over time (p = .018, part. η^2 = .080). Thus, the standard lecture had a reducing effect on the endorsement of targeted misconceptions.

To test whether *refutation lectures* had a reducing effect on refuted misconceptions, we computed a 2 (nine refuted topics vs. nine non-targeted topics) x 2 (t1 vs. t2) mixed ANOVA. There were significant main effects of refutation, $F(1, 115) = 171.211$, $p < .001$, part. η^2 = .598, and of time, $F(1, 115) = 169.832$, $p < .001$, part. η^2 = .596, and there also was a significant interaction effect, $F(1, 115) = 63.640$, $p < .001$, part. η^2 = .356. Simple effects analyses following up on the significant interaction indicated that at t1 ($p < .001$, part. η^2 = .112) and t2 ($p < .001$, part. η^2 = .631), preservice teachers had less misconceptions about the topics that would be refuted than about the topics that would not be targeted in the lecture and that both the refuted misconceptions ($p < .001$, part. η^2 = .619) and the non-targeted misconceptions ($p < .001$, part. η^2 = .268) were reduced over time. In accordance with our hypothesis, refutations led to a significant reduction in refuted misconceptions, however, contrary to our hypothesis, also the non-targeted misconceptions were reduced.

With regard to the second part of H1, we computed a mixed ANOVA between the two lectures regarding only the five topics that had either been targeted in the standard lecture (M_{t1} = 0.63, SD_{t1} = 0.23, M_{t2} = 0.54, SD_{t2} = 0.28) or refuted in the refutation lecture (M_{t1} = 0.57, SD_{t1} = 0.26, M_{t2} = 0.15, SD_{t2} = 0.20). There were significant main effects of lecture type, $F(1, 182) = 61.423$, $p < .001$, part. η^2 = .252, and of time, $F(1, 182) = 120.666$, $p < .001$, part. η^2 = .399, and there also was a significant interaction effect, $F(1, 182) = 53.849$, $p < .001$, part. η^2 = .228. Simple effects analyses following up on the significant interaction indicated that both the standard lecture (p = .023, part. η^2 = .028) and the refutation lecture ($p < .001$, part. η^2 = .555) led to reductions in misconceptions, and that at t1, the number of misconceptions did not differ between the two lectures (p = .106), whereas at t2, preservice

teachers from the refutation lecture had less misconceptions than preservice teachers from the standard lecture ($p < .001$, part. $\eta^2 = .397$), indicating a stronger reduction in misconception endorsement through refuting misconceptions than through only targeting them.

Regarding RQ2 about the potential of information evaluation strategies to reduce educational psychological misconceptions, we computed a dependent-samples *t*-test with all 18 topics. There was no significant difference between the number of misconceptions at t1 and t2, $t(81) = -0.797$, $p = .428$. Thus, information evaluation strategies had no reducing effect on the endorsement of misconceptions.

Enhancement of Metacognitive Monitoring Accuracy (H2, RQ3)

To test whether *standard lectures* had an enhancing effect on metacognitive monitoring accuracy that was stronger for targeted than for non-targeted misconceptions, we computed a 2 (bias index for five targeted topics vs. bias index for 13 non-targeted topics) x 2 (t1 vs. t2) mixed ANOVA. There were no main effects of targeting, $F(1, 67) = 3.767$, $p = .056$, and time, $F(1, 67) = 0.000$, $p = .990$, but there was a significant interaction effect, $F(1, 67) = 5.336$, $p = .024$, part. $\eta^2 = .074$. Simple effects analyses following up on the significant interaction showed that at t1, preservice teachers were significantly more overconfident regarding the topics that would be targeted than regarding the topics that would not be targeted in the lecture ($p = .003$, part. $\eta^2 = .128$) whereas at t2, their confidence between the targeted and non-targeted topics did not differ ($p = .887$). While one-sample *t*-tests indicated that all values of the bias index differed significantly from 0 (all *p*s < .001), in accordance with our hypothesis, the standard lecture at least led to a significant reduction in overconfidence for the targeted topics.

To test whether *refutation lectures* had an enhancing effect on metacognitive monitoring accuracy that was stronger for refuted than for non-targeted misconceptions, we computed a 2 (bias index for nine refuted topics vs. bias index for nine non-targeted topics) x 2 (t1 vs. t2) mixed ANOVA. There was a significant main effect of refutation, $F(1, 115) = 65.062$, $p < .001$,

part. η^2 = .361, and of time, $F(1, 115) = 144.174$, $p < .001$, part. η^2 = .556, and there also was a significant interaction effect, $F(1, 115) = 11.752$, $p = .001$, part. η^2 = .093. Simple effects analyses following up on the significant interaction indicated that at t1 ($p < .001$, part. η^2 = .102) and t2 ($p < .001$, part. η^2 = .348), preservice teachers were less overconfident about the topics that would be refuted than about the topics that would not be targeted in the lecture, and that overconfidence regarding both the refuted misconceptions ($p < .001$, part. η^2 = .509) and the non-targeted misconceptions ($p < .001$, part. η^2 = .330) was reduced over time. One-sample *t*-tests indicated that all values of the bias index differed significantly from 0 (all *p*s < .001), except the value of the bias index for the refuted misconceptions at t2 ($p = .507$). In accordance with our hypothesis, the refutation lecture significantly reduced overconfidence regarding all topics and this adjustment of metacognitive monitoring accuracy was stronger for refuted than for non-targeted topics.

Regarding RQ3 about the potential of information evaluation strategies to enhance metacognitive monitoring accuracy, we computed a dependent-samples *t*-test with all 18 topics. There was no significant difference between the bias index at t1 and t2, $t(81) = -1.710$, $p = .091$. One-sample *t*-tests indicated that both values of the bias index differed significantly from 0 (both *p*s < .001), indicating overconfidence before and after the intervention. Thus, information evaluation strategies had no enhancing effect on metacognitive monitoring accuracy.

Long-Term Effects Regarding Reduction in Misconception Endorsement and Enhancement of Metacognitive Monitoring Accuracy

To test whether the reducing effects on misconception endorsement and the enhancing effects on metacognitive monitoring accuracy were enduring, we only report on the approaches that yielded significant short-term effects because regarding both misconception reduction and metacognitive monitoring accuracy enhancement, it is not plausible to expect sleeper-effects. For the following analyses, only preservice teachers who participated in all three measurement

points are included, leading to a sample size of $n = 27$ for the standard-group and $n = 43$ for the refutation-group.

- Insert Table 3 around here -

To investigate possible long-term effects regarding misconception reduction for the *standard-group*, we computed a 2 (five targeted topics vs. 13 non-targeted topics) x 3 (t1 vs. t2 vs. follow-up) mixed ANOVA. We did not find a significant main effect of targeting, $F(1, 26) = 3.145$, $p = .088$, or time, $F(1, 25) = 0.874$, $p = .430$, and we also did not find a significant interaction effect, $F(1, 25) = 0.971$, $p = .392$. Thus, there were no long-term effects regarding misconception reduction through standard lectures.

To investigate possible long-term effects regarding misconception reduction for the *refutation-group*, we computed a 2 (nine refuted topics vs. nine non-targeted topics) x 3 (t1 vs. t2 vs. follow-up) mixed ANOVA. There were significant main effects of refutation, $F(1, 42) = 178.615$, $p < .001$, part. $\eta^2 = .810$, and of time, $F(1, 41) = 31.637$, $p < .001$, part. $\eta^2 = .430$, and there also was a significant interaction effect, $F(1, 41) = 22.127$, $p < .001$, part. $\eta^2 = .345$. Simple effects analyses following up on the significant interaction showed that for the refuted topics, there was a significant difference between t1 and t2 ($p < .001$), and t1 and follow-up ($p < .001$) but not t2 and follow-up ($p = .141$). For the non-targeted topics, there was only a significant difference between t1 and t2 ($p = .034$). These analyses also showed that the number of misconceptions did not differ significantly between both groups for t1 ($p = .073$), but for t2 ($p < .001$) and follow-up ($p < .001$). This indicates that refutations led to short- and long-term effects in reducing misconceptions for refuted misconceptions with a short-term spill-over effect on non-targeted misconceptions.

To investigate possible long-term effects regarding metacognitive monitoring accuracy enhancement for the *standard-group*, we computed a 2 (bias index for five targeted topics vs. bias index for 13 non-targeted topics) x 3 (t1 vs. t2 vs. follow-up) mixed ANOVA. We did not

find a significant main effect of targeting, $F(1, 26) = 1.079$, $p = .308$, or time, $F(1, 25) = 1.108$, $p = .346$, and we also did not find a significant interaction effect, $F(1, 25) = 0.857$, $p = .437$. Thus, there were no long-term effects regarding metacognitive monitoring accuracy enhancement through standard lectures.

To investigate possible long-term effects regarding metacognitive monitoring accuracy enhancement for the *refutation-group*, we computed a 2 (bias index for nine refuted topics vs. bias index for nine non-targeted topics) x 3 (t1 vs. t2 vs. follow-up) mixed ANOVA. There were significant main effects of refutation, $F(1, 42) = 68.333$, $p < .001$, part. $\eta^2 = .619$, and of time, $F(1, 41) = 25.410$, $p < .001$, part. $\eta^2 = .377$, and there also was a significant interaction effect, $F(1, 41) = 14.256$, $p < .001$, part. $\eta^2 = .253$. Simple effects analyses following up on the significant interaction showed that for the refuted topics, there was a significant difference between t1 and t2 ($p < .001$), and t1 and follow-up ($p < .001$) but not t2 and follow-up ($p = .834$). For the non-targeted topics, there was only a significant difference between t1 and t2 ($p = .011$). These analyses also showed that the metacognitive monitoring accuracy did not differ significantly between both groups for t1 ($p = .335$), but for t2 ($p < .001$) and follow-up ($p < .001$). This indicates that refutations lead to short- and long-term effects regarding metacognitive monitoring accuracy enhancement for refuted topics with a short-term spill-over effect on non-targeted topics.

Discussion

Educational psychological misconceptions among teachers can be an obstacle for reaching evidence-based practice in education (e.g., Pashler et al., 2008). To combat teachers' educational psychological misconceptions effectively, it is important to reduce the endorsement of misconceptions as well as to enhance teachers' awareness about what they know and what they do not know. Ideally, psychology instructors should achieve these effects through their teaching and make sure these effects are persistent, helping preservice teachers become teachers

who do not endorse educational psychological misconceptions. Therefore, we had a closer look at the prevalence of different educational psychological misconceptions among preservice teachers, investigated three different approaches regarding the reduction in educational psychological misconceptions and the enhancement of metacognitive monitoring accuracy, and also analyzed possible long-term effects of these approaches.

Regarding the prevalence of educational psychological misconceptions, we found that nearly two-thirds of the misconceptions we investigated were endorsed by more than half of our sample. The prevalence of the extensively investigated learning-styles misconception (i.e., 86.1%) was comparable with international prevalence rates that exceeded 80% for the same misconception (e.g., Dekker et al., 2012; Dündar & Gündüz, 2016; Ferrero et al., 2016; Gleichgerrcht et al., 2015; Howard-Jones, 2014; Lethaby & Harries, 2016; Menz et al., 2020; Pei et al., 2015; Tardif et al., 2015). Interestingly, the three misconceptions about bullying, seductive details, and brainstorming were less prevalent in Germany (60.9%, 69.5%, 74.4%) than in a previous investigation in Australia (90.8%, 93.3%, 97.5%) (Pieschl et al., 2019). These differences could either reflect cultural differences because prevalence rates of misconceptions can vary between different countries (e.g., McCutcheon et al., 1993) or methodological differences because Pieschl et al. (2019) used a forced-choice measurement with two contrary statements, whereas we used a true-false format complemented by a 10-point confidence scale. Nonetheless, in sum, our results indicate that also preservice teachers in Germany endorse many educational psychological misconceptions.

To combat psychological misconceptions and to enhance metacognitive monitoring accuracy, we investigated three approaches: standard lectures, refutation lectures, and instruction in information evaluation strategies. In accordance with our expectation, standard lectures had a short-term reducing effect on targeted misconceptions. Even though some previous studies indicate that standard psychology lectures are not sufficient to achieve a

change in students' misconceptions (e.g., Gardner & Dalsing, 1986; Vaughan, 1977), newer studies showed that standard lectures can have at least small effects on misconception endorsement (e.g., Kowalski & Taylor, 2009; Taylor & Kowalski, 2014). This is a pleasant finding because it shows that usual teaching approaches help students acquire correct knowledge. Apparently, only targeting misconceptions can be sufficient to change misconceptions in some cases—probably best when they are not fixed and therefore adaptable. At the same time, in the aforementioned studies, refutation lectures were even more effective in reducing students' misconceptions than standard lectures. This finding is in accordance with the findings from our study, showing that a refutation lecture had a large and enduring effect on refuted misconceptions and that this effect exceeded the effect of a standard lecture. In addition, we found an overarching reducing effect on misconceptions that were not even covered in the refutation lecture. Refutations have been criticized regarding their need to specifically refute each misconception on its own (see Taylor & Kowalski, 2019). Our study, in contrast, shows that misconceptions about topics that were not covered were also reduced. Preservice teachers in this study were confronted with refutations for nine different misconceptions throughout the semester. A repeated confrontation with elaborate refutations might have helped students to realize that their prior knowledge is not always correct but instead might be affected, for example, by biased thinking. It is possible that this experience transferred to other topics and, therefore, led to a spill-over effect on non-targeted topics. Based on these results, it could be assumed that a repeated confrontation with refutations addresses general mechanisms that contribute to the development and the adherence of misconceptions. However, as this is the first study showing spill-over effects, replications for other topics and populations are needed. In addition, possible reasons for these spill-over effects need to be investigated.

Because misconceptions can be formed or encouraged through cognitive biases (e.g., Blanchett Sarrasin et al., 2019; Gilovich, 1991; Lazer et al., 2018), we had developed an online-based training to educate about cognitive biases in combination with imparting strategies on

how to overcome biased thinking (see Schwarz et al., 2016), accompanied by a checklist. Unfortunately, this approach did not have a general effect on preservice teachers' educational psychological misconceptions. Thus, not only teaching preservice teachers about cognitive biases but also providing them with specific debiasing strategies, showing them when and how to apply these strategies, and supplying them with a checklist was not sufficient to reduce biased thinking—and consequently misconceptions—even though these attempts have been argued to be effective for debiasing (see e.g., Aczel et al., 2015; Maynes, 2015; O'Sullivan & Schofield, 2018). Probably, the information evaluation strategies did not reduce misconceptions because the misconceptions investigated in our sample did not originate from cognitive biases and, therefore, educating about cognitive biases did not show the anticipated results. It is also possible that one short online-intervention might not be comparable to a one-semester lecture program, either implemented as a standard or a refutation lecture; evaluation skills may take greater practice or feedback in using them. However, it could still be the case that those preservice teachers who received the intervention are better prevented from falling prey to cognitive biases—and consequently misconceptions—in the future when evaluating information. To sum up the effects on reducing psychological misconceptions in descending order, we found large effects through refutation lectures on both refuted and non-targeted misconceptions (which were enduring for refuted topics), smaller and only short-term effects through standard lectures on targeted misconceptions, and no effects through instruction in information evaluation strategies.

Besides reducing incorrect knowledge and enhancing correct knowledge, another aim of education is to increase confidence in correct knowledge (see Dutke & Barenberg, 2015). Therefore, we investigated whether the three approaches had effects on metacognitive monitoring accuracy regarding misconception endorsement. At the beginning of the semester, all preservice teachers of this study were overconfident regarding their knowledge. Previous studies (e.g., Dutke & Barenberg, 2009) indicated that standard lectures can increase students'

metacognitive monitoring accuracy. Our results are in line with this assumption because we found an increased metacognitive monitoring accuracy (i.e., lower overconfidence) regarding the targeted topics among preservice teachers in the standard lecture. The finding that overconfidence regarding targeted topics decreased to the level of non-targeted topics (which remained on the same level) indicates a specificity of targeting topics, that is, targeting is able to reduce overconfidence. Also in line with our expectation, the refutation lecture led to an enhancement of metacognitive monitoring accuracy that was stronger for the refuted topics than for the non-targeted topics. Especially for the refuted topics, there was a strong reduction in overconfidence: After the refutations, there was no evidence that the corresponding bias index was different from 0, which indicates a perfect match of performance and confidence or, in other words, an awareness about what preservice teachers know and what they do not know. In addition, the enhancement of metacognitive monitoring accuracy was enduring for the refuted topics. Again, instruction in information evaluation strategies did not have an effect on metacognitive monitoring accuracy. In other words, even though preservice teachers learned how their thinking and knowledge acquisition can be affected by cognitive biases, this did not make them more suspicious about what they know and what they do not know. Maybe, thinking a lot about debiasing led to a backfire effect, thus, enhancing the biased thinking instead of reducing it (see Beaulac & Kenyon, 2014). It could also be the case that participants had problems with transferring the newly acquired information evaluation strategies to their daily thinking habits, probably pointing to the need of specifically targeting one's knowledge. To sum up the effects on enhancing metacognitive monitoring accuracy in descending order, we found large effects through refutation lectures on both refuted and non-targeted topics (and for the refuted topics, these effects were enduring), we further found smaller and only short-term effects through standard lectures on targeted misconceptions, and no effects through instruction in information evaluation strategies.

Limitations

Even though we found promising results regarding the reduction in psychological misconceptions and the enhancement of metacognitive monitoring accuracy through refutation lectures, another approach that we had hoped to be effective was not: Instruction in information evaluation strategies did not have an impact on misconception endorsement or metacognitive monitoring accuracy. To investigate why this approach was not effective, it could have been helpful to add other dependent variables. For example, if the misconceptions did not originate from cognitive biases, it is reasonable that educating about cognitive biases did not have strong effects, and if participants did not learn anything about the biases, it is plausible that they were not able to transfer this knowledge onto their own thinking. We investigated the latter idea by analyzing how well participants were able to come up with examples of different cognitive biases for the anti-vaccination movement (i.e., as an approximation of their understanding of the cognitive biases). We found that nearly half of our sample reached more than 66% of the possible points and only a small minority did not come up with any useful ideas. Interestingly, post hoc regression analyses showed that participants' performance in the debiasing training neither predicted misconception endorsement nor metacognitive monitoring accuracy. Again, this could be explained by the assumption that the investigated misconceptions did not originate from cognitive biases and therefore, the high performance on finding examples for cognitive biases did not show any results. However, this is only one possible post hoc explanation. How instruction to recognize and avoid cognitive biases (e.g., by allowing extended guided practice and providing feedback) might prevent students from developing and maintaining misconceptions should be addressed by further research.

Another limitation of our study occurs due to its implementation as a field study. The standard lecture and the refutation lecture were held at two different universities with different instructors and different content, whereas the information evaluation strategies intervention was implemented in an online setting. While neither of the lectures investigated in this study included any specific content related to cognitive biases or evidence-based decision-making,

we do not know which other lectures our participants attended during the investigated time period. As a result, it is impossible to rule out other factors that could have had an influence on, for example, preservice teachers' reduction in overconfidence. In sum, it still has to be investigated whether the achieved results transfer to other universities, lectures, instructors, and topics as well as whether they are independent of other potential influences. Although we focused on preservice teachers and their educational psychological misconceptions in this study, we believe the underlying mechanisms to be transferable to other samples and psychological misconceptions. Nevertheless, our results should be replicated, not only among psychology instructors who explicitly educate preservice teachers but also among a broader set of other psychology instructors who address different misconceptions in other psychology subfields.

One important limitation refers to our follow-up analyses. In the literature, there are different definitions of long-term effects, ranging from days to years (e.g., Kowalski & Taylor, 2017; Lassonde et al., 2016). In this study, we defined long-term effects as occurring half a year later and investigated these long-term effects regarding the reduction in misconceptions and the enhancement of metacognitive monitoring accuracy. However, we have to acknowledge that only about half of the original sample of each group participated in the follow-up survey, and thus, the sample sizes were very small and probably selective. Another general limitation of this study is that we only collected self-report data, hence, we cannot say anything about possible behavioral consequences following the reduction in misconception endorsement. However, there was no reason for participants to provide incorrect information, hence, we believe that our results are valid.

Conclusion

Educational psychological misconceptions are highly prevalent among preservice teachers. It is a pleasant finding that standard lectures can have a positive effect on both these

misconceptions and metacognitive monitoring accuracy. However, refutation lectures are more effective at reducing misconceptions and enhancing metacognitive monitoring accuracy than standard lectures. With refutation lectures, it is even possible to reach long-term effects, which are highly desirable to ensure that students not only leave their psychology lectures with as few misconceptions as possible but also enter their professional careers with this low level of misconception endorsement. Therefore, not only university instructors of educational psychology classes in preservice teacher education but also psychology instructors in general first need to be aware about the large number of psychological misconceptions among their students. While planning their classes, university instructors should then use a refutation approach to reduce their students' misconceptions about the content that will be covered in class, and simultaneously enhance their knowledge about what they know and what they do not know. While the rationale for our study was based on previous theoretical deliberations and empirical findings regarding psychology students' psychological misconceptions in introductory psychology classes, we showed that these are also valid for preservice teachers and educational psychological misconceptions. To further extend our knowledge on how to improve psychology education, future research should first, replicate our findings with different samples and different psychological misconceptions from other subfields and second, investigate how overarching effects of refutations on non-targeted topics can be understood and enhanced in order to achieve the most effective and efficient approach to reduce psychological misconceptions.

References

Aczel, B., Bago, B., Szollosi, A., Foldes, A., & Lukacs, B. (2015). Is it time for studying real-life debiasing? Evaluation of the effectiveness of an analogical intervention technique. *Frontiers in Psychology, 6*(1120), 1–13. https://doi.org/10.3389/fpsyg.2015.01120

Barenberg, J., & Dutke, S. (2013). Metacognitive monitoring in university classes: Anticipating a graded vs. a pass-fail test affects monitoring accuracy. *Metacognition and Learning, 8*(2), 121–143. https://doi.org/10.1007/s11409-013-9098-3

Barzilai, S., & Chinn, C. A. (2020). A review of educational responses to the "post-truth" condition: Four lenses on "post-truth" problems. *Educational Psychologist, 55*(3), 107–119. https://doi.org/10.1080/00461520.2020.1786388

Beaulac, G., & Kenyon, T. (2014). Critical thinking education and debiasing. *Informal Logic, 34*(4), 341–363. https://doi.org/10.22329/il.v34i4.4203

Bensley, D. A., & Lilienfeld, S. O. (2015). What is a psychological misconception? Moving toward an empirical answer. *Teaching of Psychology, 42*(4), 282–292. https://doi.org/0.1177/0098628315603059

Bensley, D. A., Lilienfeld, S. O., & Powell, L. A. (2014). A new measure of psychological misconceptions: Relations with academic background, critical thinking, and acceptance of paranormal and pseudoscientific claims. *Learning and Individual Differences, 36*, 9–18. https://doi.org/10.1016/j.lindif.2014.07.009

Bensley, D. A., Rainey, C., Lilienfeld, S. O., & Kuehne, S. (2015). What do psychology students know about what they know in psychology? *Scholarship of Teaching and Learning in Psychology, 1*(4), 283–297. https://doi.org/10.1037/stl0000035

Bjork, E. L., & Bjork, R. A. (2011). Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L. M.

Hough, & J. R. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society* (S. 56–64). Worth Publishers.

Blanchette Sarrasin, J., Riopel, M., & Masson, S. (2019). Neuromyths and their origin among teachers in Quebec. *Mind, Brain, and Education, 13*(2), 100–109. https://doi.org/10.1111/mbe.12193

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research, 31*, 445–457. https://doi.org/10.1016/S0883-0355(99)00014-2

Chew, K. S., Durning, S. J., & van Merriënboer, J. J. (2016). Teaching metacognition in clinical decision-making using a novel mnemonic checklist: An exploratory study. *Singapore Medical Journal, 57*(12), 694–700. https://doi.org/10.11622/smedj.2016015

Commission of the European Communities. (2007). *Improving the quality of teacher education*. Communication from the commission to the Council and the European Parliament 3.8.2007. Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0392&from=EN

de Bruyckere, P., Kirschner, P. A., & Hulshof, C. D. (2015). *Urban myths about learning and education*. Elsevier.

Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology, 3*(429), 1–8. https://doi.org/10.3389/fpsyg.2012.00429

Diakidoy, I.-A. N., Kendeou, P., & Ioannides, C. (2003). Reading about energy: The effects of text structure in science learning and conceptual change. *Contemporary Educational Psychology, 28*(3), 335–356. https://doi.org/10.1016/S0361-476X(02)00039-5

Dündar, S., & Gündüz, N. (2016). Misconceptions regarding the brain: The neuromyths of preservice teachers. *Mind, Brain, and Education, 10*(4), 212–232. https://doi.org/10.1111/mbe.12119

Dunlosky, J., & Metcalfe, J. (2009). *Metacognition*. Sage Publications.

Dutke, S., & Barenberg, J. (2009). Ökonomisch anwendbare Wissenstests für teilnehmerreiche Psychologieveranstaltungen [Economic knowledge tests for large psychology courses]. In: M. Krämer, S. Preiser, & K. Brusdeylins (Eds.), *Psychologiedidaktik und Evaluation VII* [Didactics of psychology and evaluation VII] (pp. 367–376). Shaker.

Dutke, S., & Barenberg, J. (2015). Easy and informative: Using confidence-weighted true–false items for knowledge tests in psychology courses. *Psychology Learning & Teaching, 14*(3), 250–259. https://doi.org/10.1177/1475725715605627

Dutke, S., Koepcke, L., & Souvignier, E. (2016). Beiträge der Psychologie zum Praxissemester in der Lehramtsausbildung [Contributions of psychology to the practical semester in teacher training]. In M. Krämer, S. Preiser, & K. Brusdeylins (Eds.), *Psychologiedidaktik und Evaluation XI* [Didactics of psychology and evaluation XI] (pp. 61–69). Shaker.

Ferrero, M., Garaizar, P., & Vadillo, M. A. (2016). Neuromyths in education: Prevalence among Spanish teachers and an exploration of cross-cultural variation. *Frontiers in Human Neuroscience, 10*(496), 1–11. https://doi.org/10.3389/fnhum.2016.00496

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Gardner, R. M., & Dalsing, S. (1986). Misconceptions about psychology among college students. *Teaching of Psychology, 13*(1), 32–34. https://doi.org/10.1207/s15328023top1301_9

Gaze, C. M. (2014). Popular psychological myths: A comparison of students' beliefs across the psychology major. *Journal of the Scholarship of Teaching and Learning, 14*(2), 46–60. https://doi.org/10.14434/josotl.v14i2.3931

Gilovich, T. (1991). *How we know what isn't so: The fallibility of human reason in everyday life*. Free Press.

Gleichgerrcht, E., Lira Luttges, B., Salvarezza, F., & Campos, A. L. (2015). Educational neuromyths among teachers in Latin America. *Mind, Brain, and Education, 9*(3), 170–178. https://doi.org/10.1111/mbe.12086

Gregg, V. R., Winer, G. A., Cottrell, J. E., Hedman, K. E., & Fournier, J. S. (2001). The persistence of a misconception about vision after educational interventions. *Psychonomic Bulletin & Review, 8*(3), 622–626. https://doi.org/10.3758/BF03196199

Grospietsch, F., & Mayer, J. (2018). Professionalizing preservice biology teachers' misconceptions about learning and the brain through conceptual change. *Education Sciences, 8*(120), 1–23. https://doi.org/10.3390/educsci8030120

Guzzetti, B. J. (2000). Learning counter-intuitive science concepts: What have we learned from over a decade of research? *Reading and Writing Quarterly, 16*(2), 89–98. https://doi.org/10.1080/105735600277971

Hendriks, F., Seifried, E., & Menz, C. (2021). Unraveling the "smart but evil" stereotype: Pre-service teachers' evaluations of educational psychology researchers versus teachers as sources of information. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000300

Horsthemke, K. (2017). '# FactsMustFall'? – Education in a post-truth, post-truthful world. *Ethics and Education, 12*(3), 273–288. https://doi.org/10.1080/17449642.2017.1343620

Howard-Jones, P. A. (2014). Neuroscience and education: Myths and messages. *Nature Reviews Neuroscience, 15*(12), 817–824. https://doi.org/10.1038/nrn3817

Hughes, S., Lyddy, F., Kaplan, R., Nichols, A. L., Miller, H., Saad, C. G., Dukes, K., & Lynch, A.-J. (2015). Highly prevalent but not always persistent: Undergraduate and graduate student's misconceptions about psychology. *Teaching of Psychology, 42*(1), 34–42. https://doi.org/10.1177/0098628314562677

Hughes, S., Lyddy, F., & Lambe, S. (2013). Misconceptions about psychological science: A review. *Psychology Learning & Teaching, 12*(1), 20–31. https://doi.org/10.2304/plat.2013.12.1.20

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge UP.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Kendeou, P., Butterfuss, R., Kim, J., & van Boekel, M. (2019). Knowledge revision through the lenses of the three-pronged approach. *Memory & Cognition, 47*(1), 33–46. https://doi.org/10.3758/s13421-018-0848-y

Kendeou, P., Walsh, E. K., Smith, E. R., & O'Brien, E. J. (2014). Knowledge revision processes in refutation texts. *Discourse Processes, 51*(5-6), 374–397. https://doi.org/10.1080/0163853X.2014.913961

Kowalski, P., & Taylor, A. K. (2004). Ability and critical thinking as predictors of change in students' psychological misconceptions. *Journal of Instructional Psychology, 31*(4), 297–303.

Kowalski, P., & Taylor, A. K. (2009). The effect of refuting misconceptions in the introductory psychology class. *Teaching of Psychology, 36*(3), 153–159. https://doi.org/10.1080/00986280902959986

Kowalski, P., & Taylor, A. K. (2017). Reducing students' misconceptions with refutational teaching: For long-term retention, comprehension matters. *Scholarship of Teaching and Learning in Psychology, 3*(2), 1–11. https://doi.org/10.1037/stl0000082

Kuhle, B. X., Barber, J. M., & Bristol, A. S. (2009). Predicting students' performance in introductory psychology from their psychology misconceptions. *Journal of Instructional Psychology, 36*(2), 119–124.

Kultusministerkonferenz (KMK). (2004). *Standards für die Lehrerbildung: Bildungswissenschaften* [Standards for teacher education: Educational sciences]. KMK.

Kurbanoglu, S. S. (2003). Self-efficacy: A concept closely linked to information literacy and lifelong learning. *Journal of Documentation, 59*(6), 635–646. https://doi.org/10.1108/00220410310506295

Lassonde, K. A., Kendeou, P., & O'Brien, E. J. (2016). Refutation texts: Overcoming psychology misconceptions that are resistant to change. *Scholarship of Teaching and Learning in Psychology, 2*(1), 62–74. https://doi.org/10.1037/stl0000054

Lassonde, K. A., Kolquist, M., & Vergin, M. (2017). Revising psychology misconceptions by integrating a refutation-style text framework into poster presentations. *Teaching of Psychology, 44*(3), 255–262. https://doi.org/10.1177/0098628317712754

Lazer, D. M., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Metzger, M. J., Nyhan, B., Pennycook, G., Rothschild, D., Schudson, M., Sloman, S. A., Sunstein, C. R., Thorson, E. A., Watts, D. J., & Zittrain, J. L. (2018). The science of fake news. *Science, 359*(6380), 1094–1096. https://doi.org/10.1126/science.aao2998

Lee, C. (2017). Awareness as a first step toward overcoming implicit bias. Enhancing justice: Reducing bias, 289–302. https://scholarship.law.gwu.edu/cgi/viewcontent.cgi?article=2550&context=faculty_publications

Lethaby, C., & Harries, P. (2016). Learning styles and teacher training: Are we perpetuating neuromyths? *ELT Journal, 70*(1), 16–27. https://doi.org/10.1093/elt/ccv051

Macdonald, K., Germine, L., Anderson, A., Christodoulou, J., & McGrath, L. M. (2017). Dispelling the myth: Training in education or neuroscience decreases but does not eliminate beliefs in neuromyths. *Frontiers in Psychology, 8*(1314), 1–16. https://doi.org/10.3389/fpsyg.2017.01314

Maynes, J. (2015). Critical thinking and cognitive bias. *Informal Logic, 35*(2), 183–203. https://doi.org/10.22329/il.v35i2.4187

McCutcheon, L. E. (1991). A new test of misconceptions about psychology. *Psychological Reports, 68*(2), 647–653. https://doi.org/10.2466/PR0.68.2.647-653

McCutcheon, L. E., Hanson, E., Apperson, J. M., & Wynn, V. (1992). Relationships among critical thinking skills, academic achievement, and misconceptions about psychology. *Psychological Reports, 71*(2), 635–639. https://doi.org/10.2466/PR0.71.6.635-639

McCutcheon, L. E., Furnham, A., & Davis, G. (1993). A cross-national comparison of students' misconceptions about psychology. *Psychological Reports, 72*(1), 243–247. https://doi.org/10.2466/pr0.1993.72.1.243

McKeachie, W. J. (1960). Changes in scores on the northwestern misconceptions test in six elementary psychology courses. *Journal of Educational Psychology, 51*(4), 240–244. https://doi.org/10.1037/h0048569

Menz, C., Spinath, B., & Seifried, E. (2020). Misconceptions die hard: Prevalence and reduction of wrong beliefs in topics from educational psychology among preservice teachers. *European Journal of Psychology of Education*. Advance online publication. https://doi.org/10.1007/s10212-020-00474-5

Menz, C., Spinath, B., & Seifried, E. (2021). Where do pre-service teachers' educational psychological misconceptions come from? The roles of anecdotal versus scientific evidence. *Zeitschrift für Pädagogische Psychologie*. Advance online publication. https://doi.org/10.1024/1010-0652/a000299.

Newton, P. M. (2015). The learning styles myth is thriving in higher education. *Frontiers in Psychology, 6*(1908), 1–5. https://doi.org/10.3389/fpsyg.2015.01908

O'Sullivan, E. D., & Schofield, S. (2018). Cognitive bias in clinical medicine. *Journal of the Royal College of Physicians of Edinburgh, 48*(3), 225–231. https://doi.org/10.4997/JRCPE.2018.306

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest, 9*(3), 105–119. https://doi.org/10.1111/j.1539-6053.2009.01038.x

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*(2), 89–96. https://doi.org/10.1111/j.1751-228X.2012.01141.x

Patrick, H., Anderman, L. H., Bruening, P. S., & Duffin, L. C. (2011). The role of educational psychology in teacher education: Three challenges for educational psychologists.

Educational Psychologist, 46(2), 71–83. https://doi.org/10.1080/00461520.2011.538648.

Pei, X., Howard-Jones, P.A., Zhang, S., Liu, X., & Jin,, Y. (2015). Teachers' understanding about the brain in East China. *Procedia Social and Behavioral Sciences, 174*, 3681–3688. https://doi.org/10.1016/j.sbspro.2015.01.1091

Pieschl, S., Archer, J., & Budd, J. (2019, April 5-9). *Raising student teachers' awareness of their misconception regarding educational psychology* [Poster presentation]. Annual Meeting of the American Educational Research Association (AERA), Toronto, Canada.

Prinz, A., Golke, S., & Wittwer, J. (2019). Refutation texts compensate for detrimental effects of misconceptions on comprehension and metacomprehension accuracy and support transfer. *Journal of Educational Psychology*, *111*(6), 957–981. https://doi.org/10.1037/edu0000329

Roth, A., Ogrin, S., & Schmitz, B. (2016). Assessing self-regulated learning in higher education: A systematic literature review of self-report instruments. *Educational Assessment, Evaluation and Accountability, 28*, 225–250. https://doi.org/10.1007/s11092-015-9229-2

Ruhaak, A. E., & Cook, B. G. (2018). The prevalence of educational neuromyths among pre-service special education teachers. *Mind, Brain, and Education, 12*(3), 155–161. https://doi.org/10.1111/mbe.12181

Schraw, G. (2009a). Measuring metacognitive judgments. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 415–429). Routledge.

Schraw, G. (2009b). A conceptual analysis of five measures of metacognitive monitoring. *Metacognition and Learning, 4*(1), 33–45. https://doi.org/10.1007/s11409-008-0931-3

Schwarz, N., Newman, E., & Leach, W. (2016). Making the truth stick & the myths fade: Lessons from cognitive psychology. *Behavioral Science and Policy, 2*(1), 85–95. https://doi.org/10.1353/bsp.2016.0009

Serra, M. J., & Metcalfe, J. (2009). Effective implementation of metacognition. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 278–298). Routledge.

Tardif, E., Doudin, P.-A., & Meylan, N. (2015). Neuromyths among teachers and teacher students. *Mind, Brain, and Education, 9*(1), 50–59. https://doi.org/10.1111/mbe.12070

Taylor, A. K., & Kowalski, P. (2004). Naive psychological science: The prevalence, strength, and sources of misconceptions. *Psychological Record, 54*(1), 15–25.

Taylor, A. K., & Kowalski, P. (2014). Student misconceptions: Where do they come from and what can we do? In V. A. Benassi, C. E. Overson, & C. M. Hakala (Eds.), *Applying science of learning in education: Infusing psychological science into the curriculum* (pp. 259–273). American Psychological Association (Division 2).

Taylor, A. K., & Kowalski, P. (2019, April 5-9). The importance of refutational teaching in the classroom. In E. Seifried, & B. Spinath (Chairs), *Ask for evidence: Identifying, preventing and counteracting scientific and educational myths* [Symposium]. Annual Meeting of the American Educational Research Association (AERA), Toronto, Canada.

Tippett, C. D. (2010). Refutational text in science education: A review of two decades of research. *International Journal of Science and Mathematics Education, 8*(6), 951–970. https://doi.org/10.1007/s10763-010-9203-x

Van Eekelen, I. M., Boshuizen, H. P. A., & Vermunt, J. D. (2005). Self-regulation in higher education teacher learning. *Higher Education, 50*(3), 447–471. https://doi.org/10.1007/s10734-004-6362-0

van Loon, M. H., Dunlosky, J., van Gog, T., van Merriënboer, J. J., & de Bruin, A. B. (2015). Refutations in science texts lead to hypercorrection of misconceptions held with high confidence. *Contemporary Educational Psychology, 42*, 39–48. https://doi.org/10.1016/j.cedpsych.2015.04.003

van Merriënboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*(2), 147–177. https://doi.org/10.1007/s10648-005-3951-0

Vaughan, E. D. (1977). Misconceptions about psychology among introductory psychology students. *Teaching of Psychology*, *4*(3), 138–141. https://doi.org/10.1207/s15328023top0403_9

Willingham, D. T., Hughes, E. M., & Dobolyi, D. G. (2015). The scientific status of learning styles theories. *Teaching of Psychology, 42*(3), 266–271. https://doi.org/10.1177/0098628315589505

Appendix A: English Translation of the Educational Psychological Statements in Alphabetical Order

1. Attention and activity disorders (ADHD) are often triggered by sensory overload.[r]
2. Comparing classes with and without numerical marks, pupils in classes without numerical marks show less fear of achievement.*[r]
3. Differences in school performance are best predicted by the intelligence of students. (c)[r,s]
4. Especially highly engaged teachers will suffer from burnout.
5. Face-to-face bullying in school is more common than cyber bullying. (c)
6. Grade retention does not have a positive influence on poor students' performance. (c)
7. Highly gifted children show more behavioral problems than children with normal intelligence.[r,s]
8. Lessons adapted to different learning styles (e.g., auditory, visual, or kinaesthetic) lead to better performance.
9. Mentioning interesting and entertaining but not necessary details during a lesson about "X" leads to improved learning of "X".
10. Mostly, mathematical and linguistic aptitude go hand in hand. (c)[r,s]
11. One problem with dyslexia is that signs of dyslexia cannot be detected before the child starts reading and writing.*[r]
12. Reducing class sizes is an important measure to improve teachers' judgment.[r,s]
13. Single-sex education and mixed-sex education lead to comparable learning outcomes. (c)
14. Teachers are good at identifying highly gifted students.*[r,s]
15. The quality of ideas generated in joint "brainstorming" sessions is lower than the quality of ideas generated by people working alone. (c)
16. There are different types of intelligence (e.g., verbal-linguistic, logical-mathematical, or visual-spatial types of intelligence).
17. Through mental exercises / brain training or mnemonics you can increase your intelligence.[r]
18. We only use 10% of our brain.

Note. (c) indicates statements formulated to be in accordance with the current state of research. * indicates statements that are often misunderstood in our lecture programs. [r] = refuted in the refutation group; [s] = targeted in the standard group.

Table 1

Prevalence Rates of Misconception Endorsement in Percent

Topic	Misconception
1. ADHD	39.1
2. Numerical marks	69.5
3. Predictor of school performance	74.8
4. Burnout	38.3
5. Bullying	60.9
6. Grade retention	45.5
7. Highly gifted children	56.0
8. Learning styles	86.1
9. Seductive details	69.5
10. Mathematical and linguistic aptitude	70.3
11. Dyslexia	31.6
12. Class size	69.5
13. Single-sex education	32.3
14. Teachers identification of highly gifted children	20.7
15. Brainstorming	74.4
16. Multiple intelligences	87.2
17. Brain training	54.5
18. Use of the brain	36.1

Note. $N = 266$. Misconception = judging false statement as true + confidence ≥ 5 or judging true statement as false + confidence ≥ 5. An English translation of the items' wording and detailed information regarding which items were included in each group is depicted in Appendix A.

Table 2

Descriptive Statistics Regarding Misconception Endorsement and Metacognitive Monitoring Accuracy

	Misconception Endorsement		Metacognitive Monitoring Accuracy	
	M	*SD*	*M*	*SD*
Standard Lecture				
Targeted t1	0.63	0.23	4.22	2.17
Targeted t2	0.54	0.28	3.79	2.69
Non-Targeted t1	0.55	0.17	3.32	1.80
Non-Targeted t2	0.58	0.18	3.75	2.05
Refutation Lecture				
Refuted t1	0.52	0.21	2.54	2.00
Refuted t2	0.17	0.19	0.09	1.53
Non-Targeted t1	0.59	0.19	3.20	1.84
Non-Targeted t2	0.46	0.19	1.68	2.06
Information Evaluation Strategies				
Topics t1	0.58	0.15	2.77	1.66
Topics t2	0.59	0.16	3.04	1.62

Note. $N_{\text{standard-group}} = 68$, $N_{\text{refutation-group}} = 116$, $N_{\text{information evaluation strategies-group}} = 82$. See Appendix A for detailed information regarding which items were included in each group. $M_{\text{misconception endorsement}}$ = mean of misconception endorsement for according topics; values close to 0 indicate low misconception endorsement, values close to 1 indicate high misconception endorsement. $M_{\text{metacognitive monitoring accuracy}}$ = mean of bias index for according topics; values < 0 indicate underconfidence, values > 0 indicate overconfidence.

Table 3

Descriptive Statistics Regarding Misconception Endorsement and Metacognitive Monitoring Accuracy for the Follow-up Investigation

	Misconception Endorsement		Metacognitive Monitoring Accuracy	
	M	*SD*	*M*	*SD*
Standard Lecture				
Targeted t1	0.53	0.22	3.24	1.93
Targeted t2	0.47	0.30	3.16	2.77
Targeted follow-up	0.50	0.25	2.74	2.01
Non-Targeted t1	0.57	0.18	3.42	1.82
Non-Targeted t2	0.55	0.20	3.50	1.85
Non-Targeted follow-up	0.60	0.19	3.38	2.04
Refutation Lecture				
Refuted t1	0.51	0.21	2.56	2.25
Refuted t2	0.17	0.20	0.21	1.35
Refuted follow-up	0.23	0.19	0.44	1.53
Non-Targeted t1	0.56	0.16	2.89	1.63
Non-Targeted t2	0.48	0.17	1.98	1.80
Non-Targeted follow-up	0.54	0.19	2.83	1.91

Note. $N_{\text{standard-group}} = 27$, $N_{\text{refutation-group}} = 43$. See Appendix A for detailed information regarding which items were included in each group. $M_{\text{misconception endorsement}}$ = mean of misconception endorsement for according topics; values close to 0 indicate low misconception endorsement, values close to 1 indicate high misconception endorsement. $M_{\text{metacognitive monitoring accuracy}}$ = mean of bias index for according topics; values < 0 indicate underconfidence, values > 0 indicate overconfidence.