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When Personal Experience and Evidence Conflict: Using Refutation to Correct the Learning Styles Misconception

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Abstract

Refutation texts are effective for revising beliefs in neutral, science misconceptions. We investigated if refutation could be similarly effective for revising identity-based misconceptions (i.e., learning styles). In two studies, participants took a pretest assessing misconception endorsement, read a refutation text, and completed a posttest. In Study 1, refutation reduced belief in the misconception, but did not impact identification with a learning style. However, participants who revised their misconception demonstrated better memory for the text. Study 2 added a feedback manipulation to improve memory. Surprisingly, feedback condition did not predict memory for the text or belief change. However, Study 2 replicated key findings from Study 1 about belief, identification, and memory for the text. Open-response data from both studies suggest personal experience plays a role in the persistence of the misconception while learning explicit evidence facilitates belief revision. We discuss these findings and their implications for belief change in identity-based misconceptions.

Keywords: Refutation; knowledge revision; learning styles; identity; feedback

Introduction

Humans hold misconceptions. Whether these range from misunderstanding seasonal change to believing in a false link between vaccines and autism, a growing body of work seeks to identify and assess interventions to help people revise their inaccurate beliefs (e.g., Braasch et al., 2013; Butterfuss & Kendeou, 2021; Trevors & Kendeou, 2020). Existing work demonstrates that the refutation text – a text that explicitly states a misconception, refutes it, and provides correct information – is an effective tool for revising beliefs about neutral, science-based misconceptions (e.g., Broughton et al., 2010; Kendeou et al., 2014; Sinatra & Broughton, 2011). However, less research has examined if refutation is effective for more emotionally charged or identity relevant misconceptions, and particularly how factors such as emotional responses and identity may impact belief change (Zengilowski et al., 2021). These social and affective factors, which are often present in real-world settings, may further impact belief change and hinder the efficacy of refutation.

This concern is relevant given previous work suggests when people read information that conflicts with their beliefs, emotional responses may impact belief revision (Jacobson et al., 2022; Muis et al., 2020). For example, Jacobson et al. (2022) asked participants to read a refutation text debunking

misconceptions about genetically modified foods (GMFs). The researchers found that while refutation showed clear benefits on posttest, some participants experienced a backfire effect, where their belief in the inaccurate information was strengthened following refutation. Importantly, participants who demonstrated this backfire effect reported higher rates of anger and confusion after reading the text than participants who revised their beliefs. This evidence suggests that experiencing negative emotions in response to conflicting information may hinder belief change. Additional evidence for the importance of emotions comes from Muis et al. (2020), where the researchers manipulated the sentiment of refutation texts (positive or negative) and found that positive refutation texts produced the highest knowledge gains. Together, these findings support the possibility that emotions, whether positive or negative, may impact an individual's likelihood of engaging in belief revision.

Recent work has also considered the role of identity and suggests that when new information threatens the learner's worldview or identity, the learner may feel attacked by this information, which then may hinder revision (e.g., Ecker et al., 2022; Nyhan & Reifler, 2019; Trevors, 2021). For example, Trevors (2021) found when people viewed refutation texts that addressed a misconception they or their social community believed in, they reported experiencing a greater threat response to the information. Greater conflict with personal or group beliefs and greater threat response both negatively predicted learning from the text (Trevors, 2021). These findings provide evidence to suggest that revising identity-based misconceptions are particularly challenging because attempting to do so could lead to a threat response that strengthens resistance to belief change.

While negative emotional responses and identification with misconceptions may hinder belief change, existing work suggests that experiences of surprise may facilitate belief revision during refutation (e.g., Jacobson et al., 2022; Mason & Geller, 2025; Munnich & Ranney, 2019). Why might surprise be predictive? Prior work in the refutation text literature speculates that surprise may direct and reallocate the learner's attention to the relevant surprising content (Trevors et al., 2017). This hypothesis is consistent with findings in the feedback literature that suggest learners devote greater effort to encode feedback when that feedback is unexpected, which in turn benefits memory (e.g., Fazio & Marsh, 2009). While existing findings suggest surprise can facilitate belief revision, whether surprise facilitates belief

revision with identity-based misconceptions remains an open question.

In sum, prior work suggests when a person is confronted with information that conflicts with what they already believe to be true, emotions and identification with the misconception may contribute to resistance to belief change (Jacobson et al., 2022; Trevors, 2021), while surprise may facilitate successful belief change (Jacobson et al., 2022; Mason & Geller, 2025). A novel contribution of our research investigates how these factors may hinder or facilitate belief revision in a widely believed identity-based misconception: learning styles.

Learning Styles and the Meshing Hypothesis

Learning styles theory posits that people learn information best in systematic ways, such that they can be grouped into different types of learners, like visual learners and auditory learners (Pashler et al., 2008). Prior research even shows that some individuals, including educators, believe that learning styles are innate and tied to learners' neurobiology (Nancekivell et al., 2020). The learning styles theory is commonly understood to mean that learners learn best when taught in an instructional style that matches their learning style and that they do not learn as well when taught in a mismatched style. This is known as the meshing hypothesis (Pashler et al., 2008). Despite the popularity of this theory and previous research claiming to assess its validity, an extensive investigation by Pashler et al. (2008) found that the vast majority of studies do not use the proper methodology to establish that style-based instruction is effective. For those that do, they do not provide supporting evidence for this claim. However, learning styles remains a popular theory. This is problematic, as students and educators are not utilizing evidence-based techniques to support learning.

The Current Study

We conducted two studies to examine the efficacy of refutation for an identity-based misconception and further understand what factors may predict belief revision. We first conducted an exploratory, correlational study. In this first study, participants completed a pretest that assessed the strength and reason for their belief in the misconception, read a refutation text debunking style-based instruction, and then completed a posttest. While Study 1 was exploratory, we proposed three main hypotheses based on prior work (e.g., Jacobson et al., 2022, Trevors, 2021). First, we hypothesized participants would be less likely to revise their beliefs if they had a strong emotional attachment to the misconception. Second, we hypothesized participants would be less likely to change their beliefs if they identified with a learning style. Lastly, we hypothesized that participants would be more likely to change their beliefs if they reported high levels of surprise after reading the refutation text.

Study 2 followed a similar method as Study 1, but with the addition of an experimental manipulation. A key finding of Study 1 was that better memory of the text predicted belief change. Inspired by these findings, Study 2 implemented a feedback manipulation where participants received either

immediate, delayed, or no feedback to questions assessing critical topics in the text. Based on prior work (e.g., Roediger & Butler, 2011), we hypothesized that participants who received feedback (immediate or delayed) while reading the refutation text would demonstrate better memory for the text and be more likely to successfully revise their beliefs.

Study 1: Predictors of Belief Revision

Method

The preregistration for this study can be found at <https://aspredicted.org/w8nk5p.pdf>. Supplemental materials for both studies are available at <https://osf.io/ehbya>.

Participants We recruited 130 university students in exchange for course credit. Participants ($N = 30$) were excluded based on preregistered criteria (e.g., did not complete the study). We removed an additional participant due to technical difficulties. Our final sample consisted of 99 participants ($M_{age} = 20.14$ years, $SD_{age} = 2.36$ years). 79% of the sample identified as female, 17% identified as male, 1% identified as non-binary, 1% identified as "other", and 2% preferred not to answer. All participants were fluent in English and 70% reported English as their first language.

Design In this exploratory study, all participants completed a pretest assessing various components of endorsement of the misconception, read a refutation text debunking style-based instruction, and completed a posttest that mirrored the pretest. Our predictors of interest were emotional attachment to the misconception, memory for the text, and surprise while reading the text. Our outcome variables were belief in and identification with the misconception in addition to change in these responses from pretest to posttest. Please note that while we originally hypothesized that identifying with a style would negatively predict belief change, the vast majority of our sample identified with a style at pretest in both studies, violating necessary model assumptions to test this claim.

Materials For our *refutation text*, descriptions of learning styles and the meshing hypothesis were heavily inspired by Pashler et al. (2008) and Rohrer & Pashler (2012) (see OSF for complete text in both studies). The refutation text was presented in three parts. Section 1 explicitly refuted style-based instruction. Section 2 explained how sufficient evidence is lacking to support the meshing hypothesis. Section 3 provided insight as to why the misconception persists due to intuitive beliefs, despite the lack of evidence.

We assessed endorsement measures at pretest and posttest. To assess *belief in the misconception*, participants answered "Yes" or "No" to the question, "Do you believe it is true that students learn best when taught in their preferred learning style?". To assess *reasoning for the belief*, participants were asked, "Why do you believe or not believe that students learn best when taught in their preferred learning style?" and responded in an open-response format.

To assess *learning styles identity*, participants were asked,

“Do you personally identify with a learning style?”. They selected “No”, “Maybe”, or “Yes”. If they selected the latter two options, they selected if they were a visual, auditory, kinesthetic, verbal learner, or a style not listed.

To assess *emotional attachment to the misconception*, participants were asked, “Imagine someone said to you, ‘I agree that students have preferred learning styles, but I don’t believe that teaching in your preferred learning style leads to better learning.’ How upset would you feel?”. Participants selected a response on a 5-point scale (“1 - Not at all upset” to “5 - Very upset”).

To assess *surprise ratings*, participants were asked, “How surprising did you find the information in this text?”. They rated surprise using a 5-point scale (“1 - Not at all surprising” to “5 - Very surprising”).

Lastly, to assess *memory for the text*, participants were prompted to summarize the text in 2-3 sentences in an open-response format after reading the entire text. After providing their summary, participants answered three multiple-choice questions testing their memory for the main idea of each section of the text (see OSF for questions).

Procedure After giving consent, participants read a brief explanation of learning styles and the meshing hypothesis. They were required to successfully complete two multiple-choice questions (see OSF) to ensure they understood what we were referring to when using these terms. Next, participants completed a pretest assessing belief, identification with, and emotional attachment to style-based instruction.

After the pretest, they read a refutation text presented in three parts that debunked style-based instruction. Each part was presented on a separate page, and participants were required to spend at least 60 seconds on each page. After each section, participants provided their surprise ratings.

After viewing the entire text, participants completed the memory assessment. They were prompted to summarize the text and were required to spend at least two minutes on this task before proceeding to the multiple-choice memory questions. All participants then completed the posttest, which was identical to the pretest. Finally, participants reported demographics, were debriefed, and compensated.

Results

Belief in the Misconception At pretest, 92% of participants believed students learn best when taught in their preferred style. Immediately after reading the text, this percentage fell to 51%. Belief data is summarized in Figure 1.

Identification with a Learning Style At pretest, 88% of participants responded either “Yes” or “Maybe” to identifying with a learning style. Since no participants responded “Maybe” at posttest, we collapsed these responses together to indicate differing degrees of identification. After reading the refutation text, 83% of participants said “Yes” at posttest. Identity data is summarized in Figure 1.

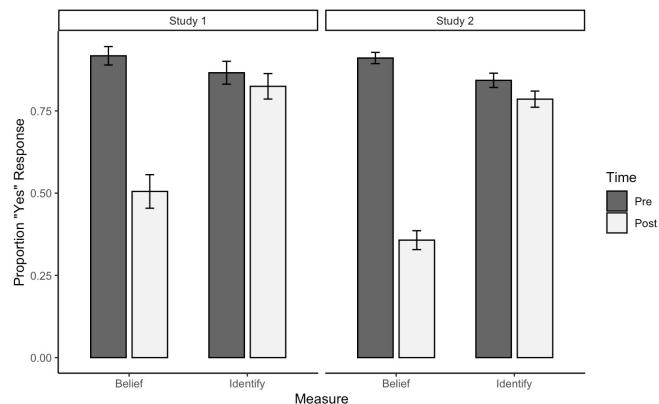


Figure 1: Belief in and identification with the learning styles misconception. Error bars denote standard error of the mean.

Predictors of Belief Revision To explore factors that predicted belief change, we filtered out participants who already rejected the misconception at pretest ($N = 8$), then separated our final sample into two groups based on belief in the misconception. One group included participants who revised their belief ($N = 42$), meaning they endorsed the misconception at pretest and rejected it at posttest. The other group consisted of participants who maintained their belief ($N = 49$) between pretest and posttest. We then ran two-sample t tests on measures of emotional attachment, surprise, and memory between the two groups. See Table 1 for averages and tests of significance for each factor.

We found that emotional attachment to style-based instruction did not differ between belief revisers and maintainers. Ratings of surprise while reading the text also did not differ between belief revisers and maintainers.

To assess memory for the text, participants’ open-response summaries were scored on a scale from -3 to 3. Participants were given 1 point for mentioning a theme from each text section. These themes included the following : (I) there is no evidence for style-based instruction, (II) few studies used the proper methodology to provide empirical support for the meshing hypothesis, (III) intuitive observations do not necessarily provide support for the efficacy of learning styles (e.g., ideas related to the learner’s preferences and/or aptitudes, topic specific benefits). If participants provided information that contradicted the correct idea, they were given -1 points. We found belief revisers scored significantly higher on these summaries than maintainers. We additionally calculated the proportion correct on the multiple-choice memory questions and found that belief revisers scored significantly higher than maintainers.

After reporting their belief in style-based instruction, participants justified their belief in an open-response format. A team of trained coders read through the open responses, identified, and agreed on recurring themes in the responses. These themes include personal experience, (e.g., “learning styles have worked for me in the past”), preferences and

Table 1: Mean scores for belief revisers and maintainers. Numbers in parentheses are standard deviations.

Predictors of Interest	Study 1		<i>p</i> -value (<i>t</i> test)	Study 2		<i>p</i> -value (<i>t</i> test)
	Revisers (<i>n</i> = 42)	Maintainers (<i>n</i> = 49)		Revisers (<i>n</i> = 153)	Maintainers (<i>n</i> = 100)	
Surprise (1-5 scale)	3.60(1.21)	3.27(.81)	.13	3.08(1.08)	3.32(1.17)	.10
Emotional Attachment (1-5 scale)	2.57(1.25)	2.55(1.02)	.93	2.20(.94)	2.54(1.18)	.01
Multiple-Choice Memory (proportion correct)	.90(.18)	.77(.26)	.005	.70(.24)	.57(.26)	< .001
Open-response Memory (Study 1 ranges [-3,3]; Study 2 ranges [-4,4])	1.36(.96)	.55(1.12)	< .001	2.00(1.07)	1.22(1.19)	< .001

comfort (e.g., “people are more comfortable with their preferred style and thus will learn better with it”), topic specific benefits (e.g., “geometry is better taught visually”), evidence (e.g., “prior research does not provide empirical support”), study habits over study style (e.g., “retrieval practice is more effective than learning styles”), and multimedia instruction (e.g., “students learn better with a combination of modalities”). Two coders independently coded each response and awarded 1 point per theme that was found. A response could earn multiple points if they mentioned multiple themes. After rating all responses, the coders went through all the responses together and resolved all discrepancies through discussion. We found that personal experience and preferences and comfort were among the most popular justifications, but that the citing of evidence was the only theme where responses increased dramatically from pretest to posttest. This data is summarized in Table 2.

Discussion

In Study 1, we found that refutation reduced, but did not eliminate belief in the misconception, and identification with learning styles was largely unaffected. Open-response data suggested personal experience with learning styles and the intuitive idea that people perform better because of comfort with a style were common reasons behind beliefs at pretest and posttest. While most themes were mentioned relatively the same number of times across pretest and posttest in Study 1, evidence was mentioned much more at posttest. We posit that this occurred because most participants were not aware of the lack of evidence supporting style-based instruction. This increase highlights that participants noticed and possibly learned explicit evidence that then impacted their belief.

A primary purpose of this study was to identify factors that predicted successful belief change. Interestingly, social or affective factors (i.e., emotional attachment) were not predictive. Rather, cognitive factors (i.e., memory for the text) did differ significantly between belief revisers and maintainers. While this evidence is correlational, we considered that memory differences may be indicative of greater attention to the text, and that better memory for the

text may facilitate revision. Perhaps, directing attention to main ideas of the text and improving memory could increase the likelihood of revision. We test this in Study 2.

Study 2: The (In)Effect of Feedback on Beliefs

Study 2 had two purposes. The first was to test whether supporting students’ memory for a refutation text (through a feedback manipulation) would better facilitate belief change. We hypothesized students would have better memory for the text and be more likely to revise their beliefs if they were given feedback compared to no feedback, as feedback should draw their attention to critical information in the text and possible inaccuracies in their understanding of learning styles. We also posit that delayed feedback would be the most beneficial, as demonstrated by prior work (e.g., Sinha & Glass, 2015). The second purpose of Study 2 was to assess whether effects obtained in Study 1 would replicate, specifically that memory for the text predicted belief change.

Table 2: Proportion of open responses including each theme.

Theme	Study 1		Study 2	
	Pretest	Posttest	Pretest	Posttest
Personal experience	.18	.22	.24	.14
Preferences and comfort	.34	.20	.29	.15
Topic specific benefits	.04	.12	.05	.10
Evidence	.05	.35	.05	.42
Study habits over style	.04	.01	.05	.03
Multimedia Instruction	.02	.05	.05	.29
Individual Differences	N/A	N/A	.17	.05

Methods

The preregistration for this study can be found at <https://aspredicted.org/4f75p2.pdf>.

Participants We recruited 316 university students in exchange for course credit. Participants ($N = 36$) were excluded based on preregistered criteria. We removed two additional participants due to technical difficulties and one participant who indicated they selected the wrong answer on the posttest. Our final sample consisted of 277 participants ($M_{age} = 20.57$ years, $SD_{age} = 2.45$ years). 82% of the sample identified as female, 16% identified as male, 0.4% identified as non-binary, 0.4% identified as “other”, and 2% preferred not to answer. All participants were fluent in English and 64% reported English as their first language.

Design Study 2 added a between-subjects manipulation to Study 1, where participants were randomly assigned to a feedback condition: immediate, delayed, or no feedback. As in Study 1, all participants completed a pretest assessing various components of endorsement of the misconception, read a refutation text debunking style-based instruction, and completed a posttest that mirrored the pretest.

Materials The refutation text was adapted from Study 1 to include a fourth section explicitly explaining the benefits of multimedia learning. The refutation text was presented in four parts. Items and scales assessing endorsement and text reactions were identical to Study 1, with a few minor word changes for readability. Again, participants summarized the text after reading it and then answered 10 new multiple-choice questions testing their memory for the text (see OSF for feedback and memory questions).

Procedure Study 2’s procedure closely mirrored Study 1. After giving consent, participants were required to complete the same two multiple-choice questions to ensure their understanding of learning styles and the meshing hypothesis. Participants then answered the same pretest questions as in Study 1.

Next, the refutation text was presented in four parts. Again, each part was presented on a separate page, and participants were required to spend at least 60 seconds on each page. After each section, participants provided their ratings of surprise.

Participants in the immediate feedback condition answered a multiple-choice question about each section of the text and received feedback immediately after reading each section. Participants in the delayed feedback condition answered all multiple-choice questions and received feedback after they finished the entire text. Participants in the no feedback condition completed no multiple-choice feedback questions.

After viewing the entire text, participants completed the memory assessment, which included the two minute open-response summary and 10 multiple-choice questions. All participants then completed the posttest, which was identical to the pretest. Finally, participants answered demographic questions, were debriefed, and compensated.

Results

All measures were coded according to the same procedures in Study 1 unless otherwise noted.

Belief in the Misconception At pretest, 91% of participants believed students learn best when taught in their preferred style. Immediately after reading the text, this percentage fell to 36%. Belief data is summarized in Figure 1.

Identification with a Learning Style At pretest, 85% of participants responded “Yes” to identifying with a learning style. After reading the refutation text, 79% of participants said “Yes” at posttest. No participants responded “Maybe” to this question at pretest or posttest. Identity data is summarized in Figure 1.

Effect of Feedback To analyze if feedback condition predicted memory for the text (open-response summary and/or multiple-choice score) or belief change, we ran three generalized linear models, with feedback condition as our predictor. To test the effect of feedback condition, we conducted nested model comparisons using Type III sums of squares. We found that feedback condition did not predict scores on the multiple-choice memory test ($\chi^2(2) = 4.86, p = .09$), open-response summary scores ($\chi^2(2) = 0.16, p = .92$), or belief change ($\chi^2(2) = 3.82, p = .15$).

Predictors of Belief Revision As in Study 1, we filtered out participants who already rejected the misconception at pretest ($N = 24$). We then separated our sample into belief revisers ($N = 153$) and maintainers ($N = 100$). See Table 1 for group averages and tests of significance for each factor.

We found that emotional attachment to style-based instruction at pretest was significantly lower for belief revisers than maintainers. However, ratings of surprise while reading the text did not differ between revisers and maintainers.

To assess memory, open-response coding followed the same approach as Study 1, but with an additional point for a new text section addressing the scientific merit of multimedia learning. Thus, participant summary scores ranged from -4 to 4. We found that belief revisers had significantly higher scores on the open-response summaries as compared to maintainers. Additionally, revisers answered a significantly greater proportion of questions correct on the multiple-choice memory assessment than maintainers.

As in Study 1, after reporting their belief in style-based instruction, participants justified their belief in an open-response format. The same team of trained coders followed the same procedure as in Study 1, but with the addition of coding for the topic of individual differences (e.g., “everyone learns differently”). We found similar patterns to Study 1. Personal experience and preferences and comfort were the most popular justifications. Evidence was also cited more from pretest to posttest. However, in Study 2, we found that the explicit mention of multimedia learning increased from pretest to posttest. These data are summarized in Table 2.

Discussion

In Study 2, we replicated key findings from Study 1 that refutation reduced, but did not eliminate belief in the misconception and that identification with the misconception was largely unaffected. Again, personal experience and comfort with a preferred style were common reasons given to justify beliefs about style-based instruction. However, the proportion of responses citing the lack of evidence supporting learning styles and the scientific merit of multimedia instruction increased at posttest. We posit that this change for both topics was likely caused by participants' lack of previous knowledge on these two topics and that learning this information then impacted their beliefs. However, in contrast to Study 1, we found that belief maintainers reported greater emotional attachment to the misconception at pretest. We speculate that this difference may be due to Study 2's larger sample size. Since this finding differs in both studies, we stray from strong interpretations of it and suggest additional future testing.

Unexpectedly, feedback did not predict memory for the text or belief change. We discuss possible explanations and relevant future directions in the General Discussion.

General Discussion

Across two studies, we explored whether a refutation text – a typically effective tool for knowledge revision for neutral, science misconceptions – could also be effective for facilitating belief revision in an identity-based misconception. We found that refutation decreased, but did not eliminate belief in the learning styles misconception. Moreover, even after reading the refutation text, the vast majority of participants still identified with a learning style. These findings suggest that refutation can encourage belief revision in an identity-based misconception, but that there may be a discrepancy between belief in and identification with the misconception that makes identification particularly resistant to change. In the case of learning styles, a lack of change in identification may be in part due to the belief that learning styles are innate and tied to learners' neurobiology (Nancekivell et al., 2020) or that modality preferences exist, even if the meshing hypothesis is not validated. However, it should be noted that we investigated only one type of identity-based misconception. The effect of refutation may vary for other types of identity-based misconceptions, particularly for those that are more central to one's identity than learning styles. Future work should investigate how refutation might influence belief in and identification with different identity-based misconceptions.

A second question explored the social, affective, and cognitive factors that may influence belief change. Contrary to our hypotheses, both emotional attachment to the misconception and surprise while reading the refutation text did not reliably predict belief change. However, belief revisers demonstrated better memory for the text than maintainers. These studies provide initial evidence to suggest cognitive factors (i.e., memory) may be more implicated in

belief revision than the predicted social factors, even within an identity-based misconception.

As such, the correlational evidence obtained in Study 1 between memory and belief change raises the possibility that capitalizing on cognitive factors like memory could improve the likelihood of belief change. We attempted to test this in Study 2, implementing a feedback manipulation. However, our manipulation did not influence memory for the text or belief change. These null results are unexpected given prior work demonstrating that feedback improves memory and that immediate and delayed feedback produce differing results (e.g., Roediger & Butler, 2011; Sinha & Glass, 2015). We speculate that these null results occurred due to a very short delay between presenting feedback before participants answered the posttest questions. Future research should implement a much greater delay between when feedback is given and when participants consider their belief at posttest to tease out the possible effects of immediate, delayed, and no feedback on belief change.

However, as demonstrated by the open-response data, there are factors beyond those we predicted that influence people's belief in the misconception. The most popular justifications for beliefs were personal experience and evidence. Notably, about a quarter of participants mentioned personal experience to justify their belief in style-based instruction. Thus, belief may be explained by students having experience with the learning style "working". While text-based interventions can address flawed logic, it is a challenge to refute personal experience. The frequency with which personal experience was cited supports the need to consider addressing personal experience and how it conflicts with empirical evidence when designing effective interventions. Additionally, evidence was often cited in people's reasons for their belief at posttest, suggesting that participants may not have originally known about lacking evidence and thus, valued the inclusion of data in advising their beliefs. We note that these findings are consistent with research by Nancekivell and colleagues (2021), who also found that personal experience with learning styles was often cited by belief maintainers following a brief intervention, and that evidence was often cited by belief revisers. Taken together, these findings shed light on additional factors that were not predicted that may impact belief in the misconception and provide support that evidence is crucial in an effective intervention, even if contradicting personal experience somewhat prevails.

Conclusion

These findings provide a starting point for future work exploring the efficacy of refutation for identity-based misconceptions and highlights the importance of distinguishing belief and identity in future demonstrations. Understanding the extent to which refutation may be beneficial in correcting identity-based misconceptions provides greater insight into why these misconceptions persist and provides relevant considerations for designing effective interventions to promote accurate understandings.

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