The Effects of Positive and Negative Emotions on Knowledge Revision

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Abstract

Across three experiments, we sought to determine the effects of positive and negative emotional content in refutation texts on correcting controversial misconceptions about vaccines. The addition of negative emotional content to texts that identify, refute and explain vaccine misconceptions improved knowledge revision observed during reading (Experiment 1). However, the addition of positive emotional content to refutation texts weakened this effect (Experiment 2). A direct comparison between negative and positive emotional content provided corroborating evidence for these findings (Experiment 3). Across experiments, results show that all refutation texts (with or without positive or negative emotional content) improved learning assessed after reading. These findings show the differential effects of emotional content on revising misconceptions about a controversial topic and provide consistent support for refutation texts as an effective tool in these corrective efforts.

Keywords: emotions, knowledge revision, refutation texts, misconceptions, vaccination

Educational Impact and Implications Statement

The present studies show that refutation texts are a reliable educational tool to correct misconceptions about vaccination, which is a controversial topic that has been previously resistant to revision efforts. The findings also show the differential effects of emotional content may hinder or enhance revision of misconceptions. These novel findings may be practically meaningful for those who are concerned with enhancing and extending the benefit of corrective messages or fact-checks to a wider audience – particularly in online contexts where content is processed in seconds and strongly competes for attention – since knowing how to give corrective messages an advantage is valuable.

Falsehood flies, and the Truth comes limping after it.

– Jonathan Swift (1710)

Fake news is not new but the intense speed with which it now travels is (Vosoughi, Roy, & Asal, 2018). Advances in information communication technologies have dramatically sped its propagation, outpacing society's typical corrective institutions, like science, education, and journalism. The qualities of misinformation that enable it to thrive online may be amplified when its subject is controversial, namely when there are multiple stakeholders with conflicting incentives, ideas, and prior commitments (Johnson, 2015). One such subject is vaccinations. Misconceptions about such issues often last longer in online discourse because they are more immune to corrective efforts (Nyhan, Reifler, Richey, & Freed, 2014; Pluviano, Watt, & Della Sala, 2017; Schmidt, Zollo, Scala, Betsch, & Quattrociocchi, 2018). A reason for the exceptional propagation and robustness of misinformation is that it may have a salient emotional dimension (Zollo et al., 2015), which may capture and consume attention (Mather & Sutherland, 2011) and motivate counterarguments and online sharing (Brady, Wills, Jost, Tucker, & Van Bavel, 2017; Nauroth, Gollwitzer, Bender, & Rothmund, 2014). However, little is known about how corrective efforts can effectively keep pace with affectively-laden misinformation. The current set of experiments addressed this issue by testing the effectiveness of one known evidence-based correction technique – refutation texts – adapted to incorporate emotional content and applied to misconceptions about vaccinations.

Misconceptions about Controversial Topics

Misconceptions about controversial and non-controversial topics are alike in that they both deviate in substantive ways from the normative and best available evidence. At minimum,

both require credible and plausible corrections to be revised (Kendeou & van den Broek, 2005; Lombardi, Bickel, Bailey, & Burrell, 2018; Rich, Van Loon, Dunlosky, & Zaragoza, 2017; Van Boekel, Lassonde, O'Brien, & Kendeou, 2017). However, controversial topics are distinguished by the involvement of multiple stakeholders whose incentives, ideas, and prior commitments are in conflict about how to resolve high-stakes issues (Johnson, 2015). For example, on the issue of vaccinations, the goals and knowledge of patients, parents, physicians, and politicians may be in conflict over the best course of action in promoting patient and population health (Hilton, Petticrew, & Hunt, 2007). Further compounding these challenges, debates surrounding vaccines have spread online, presenting uncurated information that may be contradictory and vary in accuracy (Betsch et al., 2012; Grant, 2015; Kata, 2012).

Controversial topics are also distinguished by a salient emotional dimension. In the case of vaccines, this may be parents' or patients' *confusion* over conflicting information, *fear* of serious adverse side effects, *anger* over infringements on their freedoms in following a prescribed vaccination schedule, or *disgust* over containments or violations to the body envelope (Clifford & Wendell, 2016; Dixon & Clarke, 2013; Hornsey, Harris, & Fielding, 2018; Sotiriadis et al., 2012). Such negative emotions are linked to the creation and maintenance of misconceptions that contribute to vaccine hesitancy, delay, and outright refusal, even among healthcare professionals themselves (Ashbaugh et al. 2013; Burghouts et al., 2017; Çiftci et al., 2018; Leask et al., 2012; MacDonald, 2015). Not only are emotions linked to the persistence of misconceptions about controversial topics, but they are also involved in propagation. For example, Brady and colleagues' (2017) large-scale study of social media on controversial topics showed that messages that contained emotion words were more broadly disseminated online than messages without emotion words. Further, emotional arousal, and failure to regulate it, also

impair complex learning of controversial topics online (Mason, Scrimin, Zaccoletti, Tornatora, & Goetz, 2018).

In sum, misconceptions about controversial topics pose a unique challenge to corrective efforts, in part due to their emotional dimension. What is less known is how effective are corrective techniques at revising misconceptions about emotionally-laden controversies and how they might be redesigned to enhance effectiveness for this context. Refutation texts are a promising starting point since they are an established method to correct other common misconceptions.

Knowledge Revision with Refutation Texts

Refutations texts state a misconception, refute it, and explain the correct information (Hynd, 2001). Texts that include these three components have been shown to be more effective at promoting revision of misconceptions than texts that simply state or explain the correct concept without these text features (Ariasi, Hyönä, Kaakinen, & Mason, 2017 ; Diakidoy, Mouskounti, Fella, & Ioannides, 2016; Jones, Johnson, & Campbell, 2015; Kendeou, Smith, & O'Brien, 2013; Kendeou & van den Broek, 2007; Kendeou, Walsh, Smith, & O'Brien, 2014; Trevors, Muis, Pekrun, Sinatra, & Winne, 2016; van den Broek, 2010; van Loon, Dunlosky, van Gog, van Merrienboer, & de Bruin, 2015).

To determine the processes and mechanisms that can account for why refutation texts are effective in facilitating revision, Kendeou and O'Brien (2014) proposed the Knowledge Revision Components (KReC) framework. The framework outlines five principles, two of which are assumptions and three are necessary conditions, for the knowledge revision process to be successful: encoding, passive activation, co-activation, integration, and competing activation. The *encoding principle* stipulates that information that has been encoded in long-term memory

cannot be simply erased and replaced. The *passive activation principle* refers to the passive and unrestricted way information becomes activated in memory derived from general theories of memory (Anderson, 1983). These two assumptions, taken together, posit that without intervention, misconceptions often have the potential to be reactivated and hinder subsequent learning and behavior. The KReC framework further specifies three conditions that can reduce and/or eliminate the effects of misconceptions. The *co-activation principle* states that new, correct information needs to be activated concurrently with the misconception it refutes. Co-activation is a necessary condition for the *integration principle*, which refers to the encoding of connections between correct and incorrect information in long-term memory. The integration of correct and incorrect information sets up a competition between conflicting ideas, which previous research has shown to be a necessary precondition to knowledge revision (Guzzetti, Snyder, Glass, & Gamas, 1993; Hewson & Hewson, 1984; Limón, 2001; van den Broek & Kendeou, 2008). Extending beyond the onset of conflict, the KReC framework specifies that knowledge revision will be determined by whether correct or incorrect information receives more activation in memory. The *competing activation principle* addresses this question and stipulates that as the amount of correct information increases in the integrated network – with the addition of supportive explanations and details for example – it becomes dominant by attracting more activation towards itself at the expense of the misconception. In a series of studies, Kendeou and colleagues (2013, 2014, 2018) have demonstrated that dominance of correct information is indeed a core determinant of knowledge revision success. Together, these conditions provide the mechanism that accounts for knowledge revision.

In the current studies, we developed refutation texts to revise misconceptions about vaccinations. For some texts, we included positive and negative emotional content at key points

in the text to examine their effects on knowledge revision. In the following, we review empirical research that sheds light on the potential consequences of incorporating emotional content into refutation text designs.

Emotional Content and Memory Processes

Emotional stimuli hold a competitive advantage over the memory processes involved in knowledge revision, including attention, storage, retrieval, and cognitive strategies, leading to a “winner-take-more” effect (Mather & Sutherland, 2011). In general, emotional stimuli rapidly orient and capture attention compared to neutral stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Van Bockstaele et al., 2014; Yiend, 2010) and overall, the effect is greater for negative stimuli (Baumeister, Bratslavsky, Fickenaue, & Vohs, 2001; Estes & Adelman, 2008). For instance, images of angry faces or words like “terror” consistently attract greater attention (Larsen, Mercer, & Balota, 2006; Öhman, Lundqvist, & Esteves, 2001). Negative information is theorized to have higher motivational significance based on evolutionary interpretations that there exist serious and irreversible survival consequences for failure to process and avoid threats (Alves, Koch, & Unkelbach, 2017; Rozin & Royzman, 2001) and is associated with improved reaction times and accuracy (Senderecka, 2018). Likewise, attentional capture is also present for some positive stimuli that are biologically relevant or otherwise highly motivating (e.g., erotic, nurturing, or food-related images; Gable & Harmon-Jones, 2008; Pool, Brosch, Delplanque, & Sander, 2016).

Beyond bias in attentional capture, emotional stimuli also modulate storage and retrieval of new information (Dolcos et al., 2017; Mather & Sutherland, 2011; Tyng, Amin, Saad, & Malik, 2017). Negative emotional words have a higher probability of being recalled compared to either positive or neutral words (Kamp, Potts, & Donchin, 2015). In their review, Levine and

Edelstein (2009) explain that emotional stimuli cause memory narrowing that results in a tradeoff in the kind of information that is later remembered: for central details of emotional events, memory is enhanced, whereas for peripheral details (i.e., information that is spatially, temporally, or conceptually distant from the emotional event; Kensinger, 2009), memory is diminished. This tradeoff appears to be driven by valence, as arousing negative emotional stimuli enhance memory for central details, whereas positive emotional stimuli enhance memory for both central and peripheral details (Threadgill & Gable, 2018; Yeghyan & Yonelinas, 2011).

Additionally, there are advantageous spillover effects on memory for non-emotional lexical content when embedded in emotional contexts. Neutral words (e.g., *parcel*) are more recognized when previously viewed in a negative emotional context (*The parcel contained a bomb*) compared to a neutral context (*The parcel contained a bowl*; Brierley, Medford, Shaw, & David, 2007). Davidson and Vanegas (2015) found that adding emotional content to fictional narratives enhanced subsequent recall of narrative events compared to stories where emotional content was not added. Furthermore, they found that typical narrative events directly connected to negative activating emotional content (anger) were recalled more than when connected to either positive (happy) or negative deactivating (sad) emotional content. Positive spillover effects of emotions on subsequent memory of neutral stimuli is also observed in neurobiological evidence (Ventura-Bort et al., 2016).

The effects of emotional stimuli on learning are largely consistent with the effects of emotion states. A meta-analysis of over one hundred effect sizes linked positive activating emotion states, like happiness, to enhanced creativity (i.e., generation of novel ideas), whereas negative activating states, like fear or anxiety, to reduced creativity (Baas, De Dreu, & Nijstad, 2008). Reading for pleasure and enjoyment while learning leads to more elaboration and

associations from long-term memory (Linderholm & van den Broek, 2002; Pekrun Goetz, Titz, & Perry, 2002). Similarly, other positive emotion states, like joy and interest, momentarily broaden the scope of awareness to include a wider range of perceptions, thoughts, and potential behavioral responses compared to neutral or negative emotion states (Fredrickson, 2013; Rowe, Hirsh, & Anderson, 2007; Vanlessen, Rossi, De Raedt, & Pourtois, 2014). However, a broadened focus that includes novel ideas, elaboration, and associations may not assist in comprehension and coherence-building while learning from a refutation text (Linderholm, Virtue, Tzeng, & van den Broek, 2004). In contrast, negative emotion states narrow attentional scope (Whitmer & Gotlib, 2013) and focus processing on fine-grained or local details (Bodenhausen, Gabriel, & Lineberger, 2000; Gasper & Clore, 2002), which may improve memory for central information (Kensinger, 2009). Further, negative emotion states compared to positive or neutral emotion improve reaction times, accuracy, and conscious error monitoring on several speeded choice tasks (Paul, Walentowska, Bakic, Dondaine, & Pourtois, 2017; Wiswede, Münte, & Rüsseler, 2009) and reduced susceptibility to encode false memories (Storbeck, & Clore, 2005) or incorporate false information into memory (Schmidt, Rosga, Schatto, Breidenstein, & Schwabe, 2014) may also stimulate critical thinking (Johnson & Johnson, 2009; Murphy, 2003) (for a review, see Forgas, 2013).

Emotions and Knowledge Revision

These asymmetries between emotional valence on cognitive processing can also be construed to variously hinder or support learning from refutation texts and revising incorrect knowledge. Based on the preceding review of evidence, negative emotional content may act to increase the salience of refutation information when presented in the same context, leading to heightened, focused attention, detailed processing, and improved memory for correct central

content. In contrast, positive emotional content may broaden attentional focus away from refutation content to include non-coherence building associations and heightened memory for peripheral and potentially irrelevant content. These processing differences between negative and positive emotional content have implications for the mechanism of knowledge revision proposed in the KReC – the zero-sum competition for activation between correct and incorrect concepts. Recall that the KReC theorizes that the interference from misconceptions is reduced when explanation of correct information becomes dominant in the network by drawing the majority of activation. Thus, factors that influence the allocation of activation will likewise affect the probability and strength of knowledge revision (Jones et al., 2015). This has been demonstrated by the addition of multiple explanations to refutation texts to reinforce correct concepts, which resulted in enhanced revision (Kendeou et al., 2013, 2014; Rich et al., 2017). However, we contend that the competing activation mechanism may also vary as a function of emotion. In the current studies, we extend this line of research to examine the effects of embedding positive and negative emotional content on the revision of misconceptions about controversial topics.

Present Studies

Across three experiments, we sought to determine the effects of embedding positive and negative emotional content in refutation texts and whether such texts could successfully revise misconceptions about vaccines. The current design and procedure were similar to previous studies (Kendeou et al., 2014; Van Boekel et al., 2017) wherein participants were asked to read a series of short stories that followed a narrative-informational format (Duke, 2000). The standard refutation texts included a brief introduction of a scene and two protagonists, an elaboration section that stated and refuted a targeted misconception about vaccines and explained the correct understanding conveyed via character dialogue, a filler section that continued the storyline, a

correct-outcome sentence that stated the correct belief, a spillover sentence, and a section that concluded the story. The refutation texts with emotional content followed the same structure and were otherwise identical but for one protagonist in each story expressing either positive (happy, hopeful, curious) or negative (anger, confusion, disgust, embarrassment, fear) immediately prior to the outcome sentence. Emotions were selected to reflect equivalent levels of arousal across positive and negative valence and that would also be germane to the narrative refutations. The non-refutation control texts also followed the same overall structure; however, the elaboration section in control texts neither stated nor refuted the misconception nor explained the correct understanding. Instead, elaboration sections in controls presented simple narrative details that only served to continue the story.

To the extent that negative emotional stimuli capture and consume attention, enhance memory, and promote detailed-oriented and careful processing, we predicted that negative emotional content embedded into refutations would enhance knowledge revision (Experiments 1 and 3). In contrast, to the extent that positive emotional stimuli will lead to broader, less focused attention and associations that may not be useful or possibly even detrimental to learning from refutation texts, we predicted that positive emotional content embedded into refutations would weaken text effectiveness (Experiments 2 and 3). Overall, we also predicted that refutation texts will lead to successful knowledge revision more than non-refutation control texts

We used a reading time paradigm to estimate online effects of knowledge revision and posttest measures of learning to estimate offline effects. Although reading comprehension is multifaceted, we focus on difficulty of integrating new text phrases into memory that are due to conflict between new correct information and prior misconceptions. Previous research on this specific level of comprehension has shown that reading times of phrases (measured in

milliseconds) provide a reliable and robust index of ease or difficulty of integrating text into memory (Demberg & Keller, 2008; Kaakinen, 2017; Murray & Engle, 2005; Smith & Levy, 2013), which have been additionally validated with other concurrent measures (Kendeou, Butterfuss, Kim, & Van Boekel, 2018; Kendeou & van den Broek, 2005). Specific to the current studies, reading times have been extensively used in research on the inconsistency effect (Kendeou et al., 2013, 2014; O'Brien & Cook, 2016; O'Brien, Cook, & Guéraud, 2010), which occurs when prior knowledge is inconsistent and interferes with comprehension of a specific segment of text, resulting in difficult integration and relatively slower reading times. In line with this previous research, we assumed that the speed of reading correct-outcome sentences reflects the ease of integrating that information into the conceptual network that contains the targeted misconception; slower times indicate interference from misconceptions.

Experiment 1

The goal of Experiment 1 was to assess the impact of embedding *negative emotional content* into refutation texts on knowledge revision. Previous literature has shown that negative emotions are linked to increased salience, focused attention, and detailed-oriented processing, which may enhance knowledge revision from refutation texts. Thus, we predicted that non-refutation control texts will result in the slowest reading times as misconceptions persist and continue to disrupt comprehension; standard refutation texts will result in relatively faster reading times as the interference of misconceptions will have been reduced with correct explanations; and refutations with negative emotional content will result in the fastest reading times overall as negative emotional content will enhance the cognitive processes involved in revision (reading times of correct information: non-refutation > standard refutation > negative refutation). Additionally, we predicted that posttest scores of learning from texts in Experiment 1

will be consistent with patterns of reading times (Rapp & Mensink, 2011), such that learning will be negatively influenced when readers experience more disruption from the misconceptions.

Items associated with control texts will result in the lowest scores; items associated with standard refutation texts will result in higher scores; and items associated with negative refutation texts will result in the highest scores overall (posttest scores: non-refutation < standard refutation < negative refutation).

Method

Participants

Sample size for this and all subsequent experiments were determined based on prior related research (Kendeou et al., 2013). Participants were 38 undergraduate students at a large public university in the Midwest. Their average age was 22.2 years ($SD = 5.3$ years), self-reported GPA was 3.41 ($SD = .37$), and 58% were female. Participants gave informed consent and were compensated with either \$10 or partial course credit for their approximately 1-hour participation.

Materials

Prior Knowledge. Participants were first asked to complete a prior knowledge test to assess their misconceptions about vaccines. The test consisted of nine True/False items on vaccines along with 21 additional items on other socio-scientific issues to not bias participants with foreknowledge of the topic of the study (Appendix A). Each of the nine vaccine items was specific to a misconception that was addressed by one of the texts used in the study, which are listed in Table 1. One point was awarded a correct answer and zero points for an incorrect answer. Across all experiments, participants' prior knowledge of correct vaccine concepts was low: overall average prior knowledge score was 48% ($SD = 33\%$) when corrected for guessing.

Cronbach's alpha was also low ($\alpha = .51$), which taken together, we cautiously interpret to demonstrate the presence of erroneous and fragmented prior knowledge of vaccines. To further validate the prior knowledge test, we asked participants whether they had ever refused physician-recommended vaccines for themselves and/or their children¹: those that said 'yes' to refusal (12% of sample) had significantly lower prior knowledge test scores ($M = 23\%$, $SD = 31\%$) than those that had said 'no' (88% of sample; $M = 52\%$, $SD = 32\%$), $t(108) = 3.10$, $p = .002$, $d = .92$.

Texts. Texts consisted of nine narrative-informational texts, each correcting one common misconception about vaccines (e.g., "multiple vaccines won't overwhelm the body") in dialogue between two characters. Each text included: an introduction, a within-subjects experimental section (refutation, refutation-plus-emotion, or non-refutation control), a narrative continuation section (filler or filler-plus-emotion-reinstatement), a correct outcome sentence, and a closing section (see Appendix B for an example text; all texts and materials available at: https://osf.io/hsabv/?view_only=6f3aeab47dd64dd299d18cc0ac31f495). Each section was approximately equivalent in length.

All texts began with an introduction section that established the context of the narrative ($M = 88$ words, $SD = 9$). Following this, one of three within-subjects experimental conditions was presented. The refutation condition consisted of stating and refuting the targeted incorrect belief ($M = 38$ words, $SD = 4$) and an explanation of the correct knowledge ($M = 89$ words, $SD = 6$). The refutation-plus-emotion consisted of the same refutation section with the addition of the protagonist expressing a negative emotion ($M = 46$ words, $SD = 4$) and the same explanation section. Negative emotions included anger, confusion, disgust, embarrassment, and fear (e.g., "Megan's stomach churned and she felt very disgusted"). The non-refutation control condition

¹ "Have you ever refused or elected to forgo a vaccine that your doctor recommended for you and/or your children?" [Yes/No/Prefer not to say]

consisted of equivalent narrative content that continued the storyline without mentioning either correct or incorrect knowledge (non-refutation section: $M = 44$ words, $SD = 10$; non-explanation section: $M = 99$ words, $SD = 9$). In both refutation and non-refutation conditions, a filler section followed that progressed the narrative without informational or emotional content ($M = 57$ words, $SD = 6$). The same filler section was presented in the refutation-plus-emotion condition but with the addition of the protagonist re-expressing their negative emotion (e.g., “Megan was still feeling nauseated”) ($M = 68$ words, $SD = 6$). After the filler sections, across all conditions, a correct-outcome sentence that succinctly stated the correct knowledge was presented. Reading times were recorded in milliseconds on the correct-outcome sentences. All correct-outcome sentences were within the range of 39-43 characters long ($M = 41.7$). Finally, all texts ended with a conclusion to the story ($M = 32$ words, $SD = 5$). To ensure participants were reading for comprehension, a Yes/No comprehension question was presented that required a response before proceeding onto the next text. The comprehension questions focused on basic plot details and not correct or incorrect knowledge.

Specific emotion words were selected to be equivalent in terms of emotional arousal but differ in valence (Russell, 1980). They were also selected to be germane to the specific narratives and paired with protagonists’ bodily manifestation, and equal in length (Ackerman & Puglisi, 2012).

A validation study was conducted to verify that the emotional valence across texts was perceived as designed. Forty US adults were recruited via Amazon’s mTurk platform and compensated \$2 for their approximately 25-minute participation. Demographic characteristics are presented in Table 2. Equivalent sections of refutation texts that contained the primary experimental manipulations (i.e., positive, negative, or no emotional content) were rated on 7-

point Likert scales for their relative importance (high scores reflect importance), emotional valence (high scores reflect positivity), and arousal (high scores reflect high arousal). Results showed that text differed in emotional valence ($F(2, 54) = 79.69, p < .001, \eta_p^2 = .75$) and arousal ($F(2, 54) = 14.01, p < .001, \eta_p^2 = .34$), wherein refutations with negative emotional content were perceived as more negative ($M = 2.90, SD = .90$) than refutations without emotions ($M = 4.38, SD = .39; t(27) = 9.93, p < .001, d = 1.88$), which in turn were perceived as less positive than refutations with positive emotional content ($M = 4.95, SD = .59; t(27) = 4.97, p < .001, d = .95$). Both refutation with positive ($M = 4.18, SD = .99$) and negative emotional content ($M = 4.30, SD = .76$) were rated as more arousing than refutations without emotions ($M = 3.70, SD = 1.03; t(27) = 4.59, p < .001, d = .89$ and $t(27) = 4.10, p < .001, d = .79$, respectively) but did not differ from each other, $p > .2$. Finally, all refutation texts were perceived as equally important, $F(2, 54) < 1, p > .5$.

Three material sets were constructed wherein each set contained the nine texts with three texts in each of the three experimental conditions. Across the three material sets, each text was counter-balanced to occur once in one of the three conditions. Participants were randomly assigned to a set. This counter-balancing ensured that all participants had an equal chance of being presented individual texts that appeared equally across the three experimental conditions.

Posttest. After reading, participants were asked to complete the same 9-item True/False knowledge test from the start of the study. However, posttests followed a two-tiered approach. The first tier was the typical True/False question where one point was awarded a correct answer and zero points for an incorrect answer. The second tier required participants to provide a brief open-ended explanation for their response. Participants were awarded two points for a complete and correct explanation, one point for a partially complete/correct explanation, and zero points

for an incorrect explanation. Explanations were scored by a graduate research assistant. It was possible for participants to answer the True/False question incorrectly yet still provide a correct explanation. Scores were summed to give a measure of posttest knowledge. The possible range of scores was therefore 0-3 on each question and 0-9 within each text condition. To establish that explanations were reliably scored, 20% of explanations over all studies was randomly selected and coded by the first author. Two-way random intraclass correlation showed good reliability (Hallgren, 2012), $ICC(2,1) = 0.80$, $F(192, 192) = 9.05$, $p < .001$, 95% CI [0.74, 0.85], with discrepancies resolved by discussion. Overall reliability was acceptable (Cronbach's $\alpha = .78$).

Procedure

Participants were greeted and informed that they would be reading texts on a computer as part of a study on reading comprehension. Each trial began with the word READY in the center of the screen and consisted a whole text (Introduction to Conclusion) that was separated into lines of approximately seven words each. Participants were instructed to read for comprehension at their normal pace. They were also instructed to rest their dominant hand on the space bar of a keyboard (line-advance key) to progress through the text as they read. After reading one line and ready to move on to the next, they pressed the line-advance key. Each press erased the current line of text and presented the next line in the text. The reading time was measured as the time between presses. Once participants finished reading a text, the word QUESTIONS appeared in the center of the screen for 2000 ms followed by the comprehension question. Participants responded by pressing either the “Yes” or “No” key. On the trials in which participants responded inaccurately, the word ERROR appeared in the middle of the screen for 750 ms. To ensure participants were familiar with the experimental procedure, participants read three practice texts prior to the experimental refutations.

After reading all texts, participants completed the 9-item posttest and were instructed to answer to the best of their knowledge. Following the posttest, participants completed a short demographics questionnaire, debriefed, and thanked for their time.

Results

In this and all subsequent experiments, reading times of outcome sentences that were greater than 3 *SDs* from the mean or less than 750 ms were discarded. Further, data for participants with reading times that exceeded these limits at three or more instances were discarded. As a result, all experiments, outliers representing 3% of total observations were deleted and data from 7 participants were excluded.

Reading Times

Descriptive statistics for reading times are reported in Table 3. Text condition (standard refutation, refutation-plus-negative-emotion, or non-refutation) was entered into a repeated measures ANOVA² along with material set, entered as a blocking variable. The results showed that reading times of correct outcome sentences significantly differed between text conditions $F(2, 60) = 15.74, p < .001, \eta_p^2 = .34$. Consistent with hypotheses, planned post-hoc *t* tests showed that correct outcome sentences in refutation-plus-negative-emotion texts were read the fastest overall ($M = 1770, SD = 372$) compared to both non-refutation control ($M = 2263, SD = 553; t(32) = 5.15, p < .001, d = .82$) and standard refutation texts ($M = 2030, SD = 524; t(32) = 3.16, p = .004, d = .54$). Further, outcome sentences in refutation texts, were read faster than in non-refutation control texts ($t(32) = 2.74, p = .01, d = .39$).

Posttest Scores

² Prior knowledge inconsistently correlated with posttest scores and therefore was not included as a covariate in analyses. However, when prior knowledge was included as a covariate, differences between experimental conditions remained significant.

Descriptive statistics for posttest scores are reported in Table 4. A similar repeated measures ANOVA was performed on posttest scores. Results showed that performance on posttest items significantly differed between text conditions, $F(2, 60) = 6.74, p = .002, \eta_p^2 = .18$. Consistent with hypotheses, planned post-hoc t tests showed that items targeted by refutation ($M = 6.94, SD = 1.90$) and refutation-plus-negative-emotion texts ($M = 6.73, SD = 2.20$) were both significantly higher than performance on the items targeted by non-refutation control texts ($M = 5.88, SD = 1.87; t(32) = 3.96, p < .001, d = .70$ and $t(32) = 2.90, p = .007, d = .50$, respectively), however, there was no significant difference between either type of refutation text ($p > .5$).

Discussion

The results demonstrate the effectiveness of the current set of refutation texts to promote online and offline knowledge revision of controversial misconceptions. Further, we hypothesized that negative emotional content embedded into refutation texts would enhance knowledge revision above and beyond the beneficial effects typically observed with refutation texts. This prediction was supported by reading times but not posttest scores, wherein both refutation and refutation-plus-negative-emotion texts were equivalently advantageous. One interpretation of these findings is that the effect of negative emotional content in this context is temporary and/or limited to affecting cognitive ease of integration as measured by the reading time measure during encoding but does not influence retrieval processes involved in subsequent posttest performance. An alternative interpretation is that it may be that reading time measurement had the requisite sensitivity to detect an effect of negative emotional content whereas posttest assessment of declarative knowledge did not. Overall, faster reading times with refutation-plus-negative-emotions are consistent with literature that shows the advantageous effects of negative emotional stimuli on some online cognitive and memory processes (Alves et al., 2017; Baumeister et al.,

2001; Estes & Adelman, 2008; Gasper & Clore, 2002; Kamp et al., 2015; Larsen et al., 2006; Öhman et al., 2001; Senderecka, 2018; Threadgill & Gable, 2018) and extends these findings to knowledge revision of misconceptions about controversial topics. We sought next to determine whether the effects of positive emotional content on knowledge revision.

Experiment 2

The goal of Experiment 2 was to assess the impact of embedding *positive emotional content* into refutation texts on knowledge revision. Previous literature has shown that positive emotions have been linked to broader and less focused attention and heightened memory for peripheral information that may not be useful or possibly even detrimental to knowledge revision from refutation texts. Thus, we predict that non-refutation control texts will continue to result in the slowest reading times; refutation texts will result in the fastest reading times; but refutations with positive emotional content will result in reading times that fall between non-refutation and refutation texts, since the positive emotional content will have diminished the cognitive processes involved in revision and some disruption from misconceptions will persist (reading times of correct information: non-refutation > positive refutation > standard refutation). We also predicted that posttest scores will be consistent with patterns of reading times, such that learning will be negatively influenced when readers experience more disruption from the misconceptions. Items associated with control texts will result in the lowest scores; items associated with standard refutation texts will result in the highest scores; and items associated with positive refutation texts will result in scores that fall in-between (posttest scores: non-refutation < positive refutation < standard refutation).

Method

Participants

Participants were 36 undergraduate students at a large public university in the Midwest ($N = 36$). Their average age was 20.3 years ($SD = 3.3$ years), self-reported GPA was 3.43 ($SD = .47$), and 61% were female. Participants gave informed consent and were compensated with either \$10 or partial course credit for their approximately 1-hour participation.

Materials

Texts. The same texts from Experiment 1 were used with the following modification. In the negative emotional content in the refutation-plus-emotion were replaced by protagonist expressing positive emotions, including happiness, hopefulness, and curiosity. There was no change in the length of the texts nor changes made to refutation or non-refutation control conditions.

Three material sets were constructed wherein each set contained the nine texts with three texts counter-balanced in each of the three experimental conditions. Across the three material sets, each text was counter-balanced to occur once in one of the three conditions. Participants were randomly assigned to a set.

Posttest. The posttest was the same as Experiment 1.

Procedure

The same procedure was used as in Experiment 1.

Results

Reading Times

Descriptive statistics for reading times are reported in Table 3. Text condition (standard refutation, refutation-plus-positive-emotion, or non-refutation) was entered into a repeated measures ANOVA along with material set, entered as a blocking variable. The results showed

that the difference in reading times of correct outcome sentences between text conditions did not reach statistical significance $F(2, 64) = 2.88, p = .064, \eta_p^2 = .08$. Consistent with hypotheses, planned post-hoc t tests showed that correct outcome sentences in refutation texts ($M = 1990, SD = 483$) were read faster than non-refutation control ($M = 2162, SD = 534; t(34) = 2.48, p = .018, d = .31$), however, refutation-plus-positive-emotion texts ($M = 2047, SD = 443$) did not significantly differ from either ($ps > .1$).

Posttest Scores

Descriptive statistics for posttest scores are reported in Table 4. A repeated measures ANOVA was performed on posttest scores. Results showed that performance on posttest items significantly differed between text conditions, $F(2, 64) = 12.30, p < .001, \eta_p^2 = .28$. Consistent with hypotheses, planned post-hoc t tests showed that items targeted by refutation ($M = 6.82, SD = 1.30$) and refutation-plus-positive-emotion texts ($M = 6.71, SD = 1.79$) were both significantly higher than performance on the items targeted by non-refutation control texts ($M = 5.57, SD = 1.58; t(34) = 4.16, p < .001, d = .70$ and $t(34) = 4.21, p < .001, d = .60$, respectively), however, there was no significant difference between either type of refutation text ($p > .65$).

Discussion

In line with our predictions, mean reading time of outcome sentences in refutation-plus-positive-emotion texts fell in-between refutation and control texts; however, reading time of refutations-plus-positive-emotion texts did not statistically differ from either, limiting strong conclusions to be drawn about the effect of positive emotional content during reading. As expected, standard refutations resulted in significantly faster reading times compared to controls, thus replicating the original effect obtained in Experiment 1. Additionally, both standard

refutation and refutation with positive emotional content resulted in significantly higher posttest performance compared to controls.

Several theoretical, methodological, and statistical explanations for these results are possible, and all should be regarded as provisional. One possibility consistent with previous literature is that refutations with positive emotional content may have led to reduced attentive focus on the central informational content of the text to the extent that the typical online refutation effect was weakened (Yeghyan & Yonelinas, 2011; Wadlinger & Isaacowitz, 2006). As a result, refutation-plus-positive-emotion texts did not show superiority from control texts in terms of reducing interference from misconceptions during reading as reflected by reading times. That these texts did significantly outperform controls on posttest scores, however, suggests that while the beneficial revision effect may have been weakened online, it remained intact in subsequent posttest recall and comprehension. One explanation for this ‘inconsistency’ may be statistical. Specifically, the range in reading time difference between standard refutation and control texts is small. Thus, a weakened refutation effect online (as was the case with the refutation-plus-positive-emotion) will manifest in reducing this difference even more within an already restricted range, thus limiting the potential for statistical significance (even though the means are in the expected direction). Posttest scores do not suffer from such a restricted range, thus allowing the effect to manifest as expected. Other theoretical interpretations for the discrepancy between online and offline results are also possible and will be discussed in the General Discussion. Nevertheless, questions remain whether differences for positive and negative emotional content observed in Experiments 1 and 2 would be replicated when they are directly compared.

Experiment 3

The goal of Experiment 3 was to directly contrast positive and negative emotional content embedded into refutation texts against each other and non-refutation control texts. We predicted that non-refutation control texts will result in the slowest reading times; refutation with negative emotional content will result in the fastest reading times overall; and refutations with positive emotional content will result in reading times that fall in-between (reading times of correct information: non-refutation > positive refutation > negative refutation). Building on findings from Experiments 1 and 2, we also predict that posttest scores will be higher for items targeted by refutation-plus-emotion texts (regardless of emotional valence) than control texts, but that two refutation conditions will not differ from each other.

Method

Participants

Participants were 45 undergraduate students at a large public university in the Midwest ($N = 45$). Their average age was 19.4 years ($SD = 1.2$ years), self-reported GPA was 3.29 ($SD = .42$), and 69% were female. Participants gave informed consent and were compensated with either \$10 or partial course credit for their approximately 1-hour participation.

Materials

Texts. The same refutation-plus-emotion texts from Experiment 1 (negative) and Experiment 2 (positive) were used. Additionally, the same non-refutation control texts from previous experiments were used.

Three material sets were constructed wherein each set contained the nine texts with three texts in each of the three experimental conditions. Across the three material sets, each text was counter-balanced to occur once in one of the three conditions. Participants were randomly assigned to a set.

Posttest. The posttest was the same as Experiment 1.

Procedure

The same procedure was used as in Experiment 1.

Results

Reading Times

Descriptive statistics for reading times are reported in Table 3. Text condition (refutation-plus-negative-emotion, refutation-plus-positive-emotion, or non-refutation) was entered into a repeated measures ANOVA along with material set, entered as a blocking variable. The results showed that reading times of correct outcome sentences significantly differed between text conditions $F(2, 82) = 7.64, p < .001, \eta_p^2 = .16$. Consistent with hypotheses, planned post-hoc t tests showed that correct outcome sentences in refutation-plus-negative-emotion texts were read faster ($M = 1758, SD = 418$) than either non-refutation control ($M = 2034, SD = 563; t(43) = 3.96, p < .001, d = .55$) and refutation-plus-positive-emotion texts ($M = 1931, SD = 561; t(43) = 2.87, p = .006, d = .41$). Refutation-plus-positive-emotion and non-refutation texts again did not differ ($p > .2$).

Posttest Scores

Descriptive statistics for posttest scores are reported in Table 4. A repeated measures ANOVA was performed on posttest scores. Results showed that performance on posttest items significantly differed between text conditions, $F(2, 82) = 7.45, p = .001, \eta_p^2 = .15$. Consistent with hypotheses, planned post-hoc t tests showed that performance on items targeted by refutation-plus-negative-emotion texts ($M = 6.80, SD = 2.42$) and refutation-plus-positive-emotion texts ($M = 7.00, SD = 2.07$) were significantly higher than performance on the items targeted by non-refutation control texts ($M = 5.86, SD = 2.11; t(43) = 3.37, p = .002, d = .50$ and

$t(43) = 3.34, p = .002, d = .49$, respectively). Refutation texts did not differ from each other ($p > .5$).

Discussion

The results provided support for our hypotheses. Replicating the results from Experiments 1 and 2, refutation-plus-negative-emotion texts promoted the typical refutation effect during online reading comprehension, whereas refutations-plus-positive-emotions weakened this effect. This is notable because other than the difference in valence in emotional content, these texts are identical. These consistent findings suggest that, within the context of learning from refutation texts, the inclusion of negative emotional content (e.g., fear) enhances the cognitive processes involved in revision. Previous research suggests mechanisms for these effects might be attention, storage, retrieval, or detailed and careful processing, all of which contribute to internalizing the correct explanations presented in the refutation text and promote easier integration of correct outcome sentences. Conversely, the inclusion of positive emotional content (e.g., happiness) appear to dilute attention, diminishing the effectiveness of refutation text as a vehicle for correct explanations and allowing disruptive impact on integration from misconceptions to persist. Further, consistent with Experiments 1 and 2, refutations did not differ in terms of posttest performance regardless of emotional valence, suggesting that the effects of emotional content is temporary and limited to initial exposure.

General Discussion

In a set of three experiments, we examined the effects of embedding positive and negative emotional content in refutation texts and whether such texts could successfully revise misconceptions about vaccines. Overall, the findings show that refutations (standard or including emotional content) are a reliably effective tool to revise beliefs in vaccine misinformation when

compared to non-refutation control texts. This finding is important and timely. Roughly a third of US states allow personal belief exemptions from school immunization requirements (National Conference of State Legislatures, 2017), the use of which have been linked to outbreaks of vaccine-preventable diseases (Immunization Action Coalition, 2016; Phadke, Bednarczyk, Salmon, & Omer, 2016). This year, the Centers for Disease Control and Prevention (2019) identified vaccine misinformation as a significant factor contributing to the highest number of measles cases in the US since it was declared eliminated nearly two decades ago. Thus, it is critical to identify evidence-based methods to correct beliefs in vaccine misinformation. However, such misconceptions have been notoriously resistant to previous correction efforts (Schmidt et al., 2018). Past research found that attempts to correct vaccine misconceptions were ineffective and, in some cases, backfired (Nyhan et al., 2014; Pluviano et al., 2017). Refutation texts may overcome this resistance due to their design, which includes direct mention and refutation of the misconception along with elaborative explanations of the correct idea in close proximity in the text. This design facilitates competition and dominance of correct information over prior misconceptions (Kendeou et al., 2013, 2014). Therefore, we surmise that the positive difference observed in the current studies may be due to the qualities of the design of refutation texts.

With respect to the effects of embedded emotional content in refutation texts, the current findings are among the first to offer insights into the role of emotional content on knowledge revision. The results show how online effects of the refutation text structure varied as a function of the inclusion of negative or positive emotional content. In the current studies, negative emotional content augmented online revision above standard refutations, as demonstrated by faster reading times of correct outcomes. According to the Knowledge Revision Components

framework (KReC; Kendeou et al., 2013, 2014), this result is predicted when correct information is coactivated and integrated with misconceptions and becomes dominant in that network to the point of reducing the reactivation of erroneous knowledge. When negative emotional content is attached to refutations, this may increase the salience, and thus activation, of correct information. The advantage in competition for limited activation may facilitate encoding and lead to a more detailed memory of refutations, which in turn eases the integration of correct outcome sentences. In contrast, the inclusion of positive emotional content in refutations weakened online revision as indicated by slower reading times. According to the KReC, this reflects that misconceptions continued to be reactivated and disrupt comprehension. The interruptive reactivation of misconceptions occurs when correct knowledge is not sufficiently encoded and thus does not become dominant in the integrated semantic network. Conceptual dominance varies as a function of the quality of attention and other cognitive processes. Thus, from the current results we conclude that the interaction between refutation text structure and positive emotional content resulted in a weakened competing activation advantage for correct content.

These findings are consistent with theories on the relations between emotional stimuli and cognitive processes. Consistent with a competitive advantage for refutations when embedded with negative emotional content, past research found that negative emotional stimuli are linked to increased salience, focused attention, and detailed-oriented processing (Alves et al., 2017; Baumeister et al., 2001; Estes & Adelman, 2008; Gasper & Clore, 2002; Kamp et al., 2015; Larsen et al., 2006; Öhman et al., 2001; Senderecka, 2018; Threadgill & Gable, 2018). Conversely, in line with a competitive disadvantage for refutations embedded with positive emotional content, past research found that positive emotional stimuli are linked to a broadened scope of attention and heightened memory for peripheral and potentially irrelevant information,

which in the current studies may have diluted focus on central refutation content (Yegiyan & Yonelinas, 2011; Wadlinger & Isaacowitz, 2006). Additionally, the findings also demonstrate that readers regularly encode information about characters' emotions in their emerging mental text representations (Gernsbacher, Goldsmith, & Robertson, 1992; Gillioz & Gygax, 2017; Komeda & Kusumi, 2006), which subsequently influence the integration of correct outcome sentences. Thus, the current findings support theories on the spillover effects of emotional content to other, non-emotional written content (Brierley et al., 2007; Davidson & Vanegas, 2015; Ventura-Bort et al., 2016).

Notably, the aforementioned differences in reading times were not consistently reflected in post-reading measures of learning. Across these experiments, texts with any refutation structure (standard structure or with positive or negative emotions added) resulted in higher learning scores than non-refutation control texts but were not reliably different from each other. Typically, the moment-by-moment processes that occur during reading are causal antecedents to the quality of mental representations that can be assessed with offline measures, such as tests of learning, after reading has been completed (Kendeou & O'Brien, 2018). However, Rapp and Mensink (2011) suggest that discrepancies between online and offline variables offer theoretical insights into different aspects of reading comprehension. Differences found with our online measure between standard, positive, and negative refutation conditions are likely due to differences in activation, integration, or other encoding processes of correct information. In contrast, an absence of difference found with our offline measure between refutation conditions may reflect equivalence in storage and retrieval. In sum, emotional content may have differential effects on cognitive processes depending on time and type of assessment. Reading times assessed online reflect the ease of integrating new information into memory and are thus sensitive to

factors that affect integration, such as level of activation and inference generation. In contrast, posttests offline reflect retrieval and application of declarative knowledge after reading, at which point heightened activation may have dissipated or other goal-directed inferences formed. Future research is needed that uses process measures both online and offline to illuminate the exact cognitive processes occurring at encoding and retrieval.

In sum, the current findings extend knowledge of the well-established refutation text effect in two ways: 1) embedding emotional content modulates that effect; 2) the effect is modulated to favor negative emotional content and to disfavor positive emotional content. These novel findings may be practically meaningful for those who are concerned with enhancing and extending the benefit of corrective messages or fact-checks to a wider audience – particularly in online contexts where content is processed in seconds and strongly competes for attention – since knowing how to give corrective messages an advantage is valuable. While we believe that this research is the first to demonstrate the effects of emotional content on cognitive revision processes, other research has shown the threats posed by rapidly spreading emotionally-charged fake news (Vosoughi, Roy, & Aral, 2018), further underscoring the need for more research insights and solutions from educational psychologists in this area.

Limitations and Future Directions

The strength of prior belief, personal relevance of misconceptions, and perceptions of controversy are factors known to influence revision success. Participants in the current samples initially possessed low and fragmented knowledge about vaccines; we assume that findings from the current samples reflect fundamental cognitive processes that will generalize to others who possess such misconceptions. Further, given the demographics of the current samples, our participants may also at some point be involved in making personal vaccination decisions related

to influenza, meningitis, human papillomavirus, tetanus and diphtheria boosters, in preparation for some international travel, and for any vaccines they may have missed as a child (CDC, 2016). However, it is unknown to what extent participants held strong or personally-relevant prior misconceptions or believed the issue was controversial, all of which may impact revision. It will therefore be important to determine whether positive educational effects of refutation texts can be generalized to samples with strong aversions to corrective messages about vaccines. It will also be important for future research to examine the interaction between participants' own moment-by-moment emotion and cognitive processes during knowledge revision to build off the current research and research on self-reported emotion (Broughton, Sinatra, & Nussbaum, 2012; Heddy, Danielson, Sinatra, & Graham, 2017; Muis et al., 2018). Further, we surmised that emotional content exerts its effects on online comprehension via differences in attention allocation and cognitive strategies. However, future research will need to directly examine the mechanisms that account for these effects. Finally, the current research did not include a delayed posttest so our knowledge is limited regarding the long-term durability of revision. Past research has shown enduring knowledge revision from refutation texts (Cordova, Sinatra, Jones, Taasobshirazi, & Lombardi, 2014; Diakidoy, Mouskounti, & Ioannides, 2011; Mason et al., 2017), which we would expect to be further modulated by emotional content (Mather & Sutherland, 2011). Overall, the integrated theoretical framework that incorporated cognitive and emotional factors we used to ground the current research also raises several other research questions to be addressed in future research, including mechanisms (e.g., asymmetrical activation by valence), boundary conditions (e.g., strength of prior beliefs), and outcome variables (e.g., delayed assessment).

Conclusions

The present study adds to the growing body of work showing that refutation texts are an effective and reliable tool to increase comprehension of correct information and revise misconceptions about vaccines – a socio-scientific topic for which there are several misconceptions especially resistant to correction. The study also provides new insights into the role of embedded emotional content in this process. Negative emotional content strengthens, and positive emotional content weakens online comprehension of correct information. These effects may be driven by differences in competing activation of correct and incorrect concepts and have implications for the potential reactivation of misconceptions. Nevertheless, the beneficial effects on immediate learning outcomes from refutation text structure are robust.

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Table 1

List of misconceptions about vaccines targeted for intervention

1. Vaccines cause full-blown illnesses
 2. Vaccine contain toxins
 3. Natural immunity is stronger than vaccine-acquired immunity
 4. Vaccines cause serious side effects like Sudden Infant Death Syndrome (SIDS)
 5. Rates of vaccine exemptions are elevated nationally
 6. Most vaccines are no longer needed
 7. Multiple vaccines overwhelm the immune system of young children
 8. Vaccine mandates are bad for society
 9. It is safe to rely on the vaccines of others
-

Table 2

Demographic statistics of validation study sample

Mean age (years)	37.5 (10.6)
Gender (% female)	42.5
Educational attainment (% sample)	
Some high school	0
High school diploma or GED	23
Associate's degree	13
Postsecondary non-degree award	0
Some college, no degree	5
Bachelor's degree	50
Master's degree	10
Doctoral or professional degree	0
Other	0

Note. Standard deviation in parentheses.

Table 3

Means and standard deviations for reading times in milliseconds across text conditions and experiments

	Refutation	Refutation with Negative Emotion	Refutation with Positive Emotion	Non-Refutation Control
Experiment 1	2030 (524)	1770 (372)	–	2263 (553)
Experiment 2	1990 (483)	–	2047 (443)	2162 (534)
Experiment 3	–	1758 (418)	1931 (561)	2035 (563)

Note. Standard deviations in parentheses.

Table 4

Means and standard deviations for knowledge posttest scores across text conditions and experiments

	Refutation	Refutation with Negative Emotion	Refutation with Positive Emotion	Non-Refutation Control
Experiment 1	6.94 (1.90)	6.73 (2.20)	–	5.88 (1.87)
Experiment 2	6.82 (1.30)	–	6.71 (1.79)	5.57 (1.58)
Experiment 3	–	6.80 (2.42)	7.00 (2.07)	5.86 (2.11)

Notes. Standard deviations in parentheses. Possible range = 0-9.

Appendix A
True/False Knowledge Test Items

1. Vaccines work by causing the full-blown symptoms of the specified disease. (F)
2. Vaccines do not contain ingredients in toxic amounts. (T)
3. Naturally-acquired immunity is stronger than vaccine-acquired immunity. (F)
4. It is common for vaccines to cause serious side effects. (F)
5. The number of people obtaining exemptions from vaccines for reasons related to their personal beliefs is very low. (T)
6. Children need vaccines even for diseases that are not common anymore. (T)
7. The immune system of young children can be overwhelmed by multiple vaccines given in a single session. (F)
8. The benefits of mandating people to get vaccinated outweigh any potential costs. (T)
9. It is a safe option for an individual to rely on the vaccination of others for protection from diseases. (F)

Appendix B

Example of One Text Across Three Experimental Conditions

Introduction (All Conditions)

Nick and Sarah had recently signed up to volunteer at the university's daycare program. Both wanted to gain extracurricular experience working with young children. They were planning to major in psychology and early childhood education and thought this was a good opportunity to gain experience working with young kids. It was almost the children's snack time when Sarah noticed that a few children were absent from daycare that afternoon. She found out that the parents of the five-year olds had taken them to get their DTaP, Polio, MMR, and chickenpox vaccines.

Non-Refutation (Control Condition)

Sarah often wondered about healthcare for children around this age. She knew these kids had a number of vaccines scheduled around this time. Sarah asked Nick if he knew anything about how vaccines might interact with their immune system.

Refutation

Sarah told Nick that she thought these children were getting too many vaccines too soon. She thought multiple vaccines would overwhelm their immune system and cause damage. Nick explained this was not true.

Refutation with Positive Emotion

Sarah tilted her head and felt very curious. She told Nick that she thought these children were getting too many vaccines too soon. She thought multiple vaccines would overwhelm their immune system and cause damage. Nick explained this was not true.

Refutation with Negative Emotion

Sarah was shaken up and felt very scared. She told Nick that she thought these children were getting too many vaccines too soon. She thought multiple vaccines would overwhelm their immune system and cause damage. Nick explained this was not true.

Non-Explanation (Control Condition)

Sarah had been learning a lot from her volunteer experience. She always knew she wanted to work with kids at this age. She used to babysit when she was younger, but really didn't have any formal job experience working with a large group of children. She was interested when her psychology classes would talk about early childhood development and was always trying to make links between what was talked about in class and the kids she worked with at the daycare. Just the other day, she and Nick were talking about seeing developmental milestones.

Explanation (All Refutation Conditions)

Nick continued to say that research has shown that healthy children's immune systems are strong at any age because human bodies have to deal with a whole host of pathogens in the world. Findings consistently demonstrate that key elements of the recommended vaccine schedule – the number, frequency, timing, order, and age of administration of vaccines – is very safe. Nick explained that what is riskier than vaccines is delaying receiving them, because this puts children at risk to contract serious and potentially life-threatening diseases.

Filler (Refutation and Non-Refutation Control Conditions)

Sarah went about preparing snacks for the children that were there that day as Nick started to clean up the toys that were scattered across the floor. There was never a dull moment volunteering at the daycare center and they were usually busy. After tidying up, Nick went over to Sarah and reassured her that [...]

Filler with Positive Emotion Reinstatement

Sarah was intrigued by these ideas. She went about preparing snacks for the children that were there that day as Nick started to clean up the toys that were scattered across the floor. There was never a dull moment volunteering at the daycare center and they were usually busy. Sarah was still feeling inquisitive. After tidying up, Nick went over to Sarah and reassured her that [...]

Filler with Negative Emotion Reinstatement

Sarah was terrified by these ideas. She went about preparing snacks for the children that were there that day as Nick started to clean up the toys that were scattered across the floor. There was never a dull moment volunteering at the daycare center and they were usually busy. Sarah was still feeling anxious. After tidying up, Nick went over to Sarah and reassured her that [...]

Outcome Target (All Conditions)

[...] multiple vaccines won't overwhelm the body.

Conclusion (All Conditions)

Nick helped Sarah finish preparing the rest of the food as the kids were ushered to their seats at the table. The children were eager to eat their snacks as they had been running around a lot and were hungry.