Just Tell the Truth: Correcting Misconceptions with Simple, Factual Statements

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Abstract

Efforts to correct misconceptions have produced multiple types of complex interventions. However, past research has consistently shown that simple, factual statements may be equally effective in activating the incorrect information and prompting an integration of the correct concept. The current study tests the effectiveness of simple statements on 76 different misconceptions. Findings indicate that for the majority of misconceptions, simple statements are an effective intervention to reduce misconceptions. Limitations and future directions are discussed.

Keywords: misconceptions, integration, learning

Introduction

Misconceptions are inaccuracies within knowledge that may include both individual facts (e.g., a cow started the Great Chicago Fire), or inaccurate connections between ideas (e.g., seasons are caused by earth's orbit, rather than earth's axial tilt). Misconceptions linger in memory and continue to influence behavior even after correction (Seifert, 2002). When a correction is given but the misconception remains, it is assumed that there has been a failure to either retrieve the correct information (i.e., the misconception to be corrected) or a failure to integrate the new information (Sanderson, Farrell, & Ecker, 2020).

Multiple interventions have been proposed and tested to address potential failures in retrieval and integration. For example, refutation texts (Sinatra & Broughton, 2011) are thought to enhance conceptual change by specifically stating the misconception (retrieval) then providing the correct concept along with supporting evidence (integration). Other techniques such as credible or socially connected sourcing (Margolin, Hannak, & Webber, 2018), or asking participants to make predictions about evidence for a misconception (Vlasceanu, Morais, and Coman, 2021) are thought to work in a similar way by enhancing retrieval, integration, or both. Finally, some interventions attempt to prevent misconceptions from occurring by inoculating individuals against future misinformation (Cook, Lewandowsky, & Ecker, 2017). Overall, several techniques have been proposed and tested to refute and reduce misconceptions across a broad spectrum of topics in in science, social science, and history.

Critically, the need to utilize increasingly complex methods to combat misinformation and misconceptions may *itself* be a misconception. For instance, studies have found that stating simple facts (e.g., human activity has caused global warming) is one of the most effective interventions to correct misconceptions about climate change (Bolsen, Leeper, & Shapiro, 2014; van der Linden et al., 2014) and political news (Vlasceanu, Morais, & Coman, 2021). Similarly, research on fact-checking political news has found that individuals find information less accurate when it is accompanied by a "disputed" or "false" tag (Clayton et al., 2020; Ecker et al., 2019); further, fact-checking is effective across different nations and the effect is durable for weeks after the initial fact-check (Porter & Wood, 2021).

Simple statements may be more effective than complex interventions in correcting misconceptions for two reasons:

First, in complex interventions, individuals are often asked to both identify conflicting information and execute a novel strategy – these tasks often require students to have developed a sufficient amount of expertise and knowledge. Indeed, prior work demonstrates that more strategic and knowledgeable learners generate more inferences and integrate more information when reading (McNamara, 2021; Ozuru, Dempsey & McNamara, 2009). In conceptual change tasks, the inference-generation process affords the learner the opportunity to identify inconsistent information. Thus, skilled learners may benefit as they can more readily generate inferences between concepts and identify inconsistent information than less skilled learners. Conversely, less-skilled learners may integrate both the correct concept and the misconception. Thus, simple statements may be a more effective intervention specifically for less-skilled learners because simple statements may be easier to comprehend.

Second, complex interventions are typically tested on one to two topics and may not be as effective across a variety of misconceptions. For example, refutation texts have shown both strong effects (Sinatra & Broughton, 2011) and null effects (e.g., Kessler, Braasch, & Kardash., 2019; Watanabe & McNamara 2021) across different topics. A prominent explanation for the divergent findings regarding refutation texts is that, in some studies, the misconceptions implicate self-identity (Trevors, 2022). Gregoire (2003) proposed a 3-tiered model that characterized the relationship between self-identity and misconceptions as either inconsequential, challenging, or threatening. For example, religious conceptions are more strongly linked to identity compared to the misconception that the Great Wall of China is visible from outer space. By identifying if misconceptions are inconsequential, challenging or threatening, simple

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statements can be tested as an intervention for different types of misconceptions.

Furthermore, simple statements may be an effective intervention simple because they offer instructional feedback (i.e., telling participants their answer is incorrect and then giving the correct answer). Past research has demonstrated the global efficacy of instructional feedback in correcting errors in learning tasks (Kulhavy, 1977). Indeed, other interventions to correct misconceptions may be confounded because participants are given some form of instructional feedback (Bangert-Drowns et al., 1991). The feedback may take the form of the correct response with an explanation or refutation (e.g., a refutation text), or a warning that the following stimulus is misleading and/or incorrect (e.g., inoculation). Thus, it is possible that positive findings on conceptual change interventions are primarily due to a testing effect from instructional feedback.

The current study seeks to expand the research on using simple statements to correct misconceptions to a broad variety of misconceptions. The misconceptions tested in the study were drawn from the domains of physical science, social science, and history. In addition, the misconceptions tested varied in complexity, as well as the degree to which they implicated participants' identity. Finally, the misconception items participants were shown were consistent or inconsistent across sessions, which allowed for analyses on whether conceptual change was stable across items, or whether participants' conceptual change was a result of them receiving feedback on a specific item.

It was hypothesized that if simple statements were an effective method of activating knowledge and affording the learner the opportunity to integrate the new concept, there would be a main effect of session such that participants would have fewer misconceptions in Session 2 than in Session 1. In addition, predicted such that there would be an interaction such that the effect of session would be greatest for participants who saw a consistent set of items between sessions.

Based on the research on inference and integration, we hypothesized that there would be interactions between prior knowledge and session and reading skill and session. Simple statements may reduce the effect of knowledge and skill such that the difference in misconceptions between high and low skill participants is attenuated in Session 2.

Further, competing hypotheses were proposed for different types of misconceptions tested (inconsequential, challenging, threatening). If conceptual change depended on the type of misconception, we hypothesized an interaction between misconception type and session such that participants would be less likely to correct misconceptions that were coded as threatening or challenging compared to misconceptions that were coded as inconsequential. In comparison, the null hypothesis was that simple statements would be effective across misconception types, and no interaction would be found.

Finally, previous studies have found effects of demographic variables such as political affiliation (Fleming et al., 2021), religious affiliation (Crosby & Yarber, 2001), news sources (Gardner & Brown, 2013), or social media usage (Ali et al., 2021) on conceptual change. We hypothesized that simple statements would be effective across demographic groups.

Method

Participants

Participants were recruited from undergraduate psychology classes (N = 130) in the United States and given course credit in exchange for participating. Participants from outside the United States were removed because the misconceptions were collected from studies involving participants from the United States. Thus, it is possible that individuals from different national, educational, and cultural backgrounds would not hold the same misconceptions as those in the United States. In addition, participants who failed to complete both sessions were removed, leaving a final n = 90. The majority of participants in the study were female (n = 66). The participants were majority Caucasian (n = 56), with smaller groups of African American (n = 6), Asian (n = 8) and Hispanic (n = 20) participants. The mean age was 19.8 (SD = 2.83), with a range of 18 - 42.

Design and Procedure

This study used a 2(Session: 1, 2) x 2(Misconception Set Consistency: Consistent, Inconsistent) within-subjects design. In Sessions 1 and 2, participants were administered a set of 76 statements to rate as either true or false. Half of the statements were misconceptions and half were facts to prevent participants from answering false on every statement.

In Session 1, participants were also given a simple statement with the correct concept after each response (e.g., "[Correct/Incorrect], *while some people think meteorites are hot when they land on earth's surface, they are in fact cold*"). Each statement was presented individually, and after answering, participants were informed if their answer was correct or incorrect. The statements were counterbalanced such that participants saw 38 misconception statements, and 38 fact statements (see Table 2).

Table 1: Statement Counterbalancing

Set Number	Topics 1-38 Type	Topics 39-76 Type
Set 1	Misconceptions	Facts
Set 2	Facts	Misconceptions

Participants were then asked to complete a prior knowledge assessment and provide demographic information. The mean time to complete the first session was 29.9 minutes (SD = 15.7 minutes).

Participants were asked to complete the second session 24-72 hours after completing Session 1. In Session 2, participants were administered 76 statements to rate true or false. Half of the participants were given the same set of

statements as in Session 1, the other half were given the reverse set of statements (Misconception Set Consistency: Consistent, Inconsistent). Table 3 shows the statement sets by session and group. Finally, participants were administered the reading skill test. The mean time to complete the second session was 34.5 minutes (SD = 4.35 minutes).

Table 2: Statement Sets by Session and Group

Group	Set Consistency	Session 1	Session 2
Group 1	Consistent	Set 1	Set 1
Group 2	Inconsistent	Set 1	Set 2
Group 3	Consistent	Set 2	Set 2
Group 4	Inconsistent	Set 2	Set 1

Materials

The research team selected a set of 76 misconception topics from three domains: physical science, social science, and history. The topics were drawn from previous peer-reviewed research (i.e., Van Boekel, et al., 2017), as well as internet resources, such as Wikipedia. The researchers generated a misconception statement and a fact statement for each topic. Table 1 contains an example of both statement types.

Table 3: Example Misconception and Fact Statements

Topic	Misconception	Fact
Meteorites	Meteorites are hot when they reach the Earth's surface.	Meteorites are cold when they reach the Earth's surface.

A rubric was developed based on Gregoire's model of cognitive-affective conceptual change (2003). Two researchers independently coded each of the topics as one of 3 types: inconsequential, challenging, or threatening. Table 4 provides examples of each type of misconception. The weighted kappa of the raters was $\alpha = 0.81$ Disagreements were adjudicated by a third researcher, and in the final dataset, each misconception topic had a single code.

Table 4: Examples of Inconsequential, Challenging, and Threatening Misconceptions

Type	Misconception Statement
Inconsequential	Cinco de Mayo is a celebration of Mexico's Independence from Spain.
Inconsequential	The Great Wall of China is the only man-made object visible to the naked eye from space.
Challenging	Most people experience unstable behavior and relationships during adolescence.
Challenging	A correlation between two variables means that one of those variables causes the other.
Threatening	Punishment is the most effective means of changing long-term behavior.
Threatening	Humans and dinosaurs inhabited the earth at the same time.

Students' prior knowledge of science, literature, and history was assessed using a 30-item measure of prior knowledge (McNamara, et al., 2006). The items were general knowledge that were not related to the misconception statements. A general test was used to assess knowledge independent of the misconceptions tested in the study because past research has indicated more knowledgeable participants are more likely to revise misconceptions in multi-session studies (Watanabe & McNamara, 2021). The reliability in the current study was $\alpha = 0.83$.

The reading comprehension test from the Gates–MacGinitie Reading Test was used to measure reading skill (GMRT; MacGinitie, 1989). The test consists of 11 short passages followed by a set of multiple-choice questions. There are 48 total multiple-choice questions in the test, and participants were given 25 minutes to answer as many questions as possible. The reliability in the current study was $\alpha = 0.93$.

Participants were asked a set of questions on their age, ethnicity, and religious affiliation. They were asked to select a political party in the United States they most identify with (e.g., Democrat, Independent, Republican, other) and what religion they identify with, if any (e.g., Buddhist, Christianity, Hindu, Islam, None, other). Participants were asked the amount of time they spend using social media, their most visited social media site and most visited news website.

Results

Table 5 shows descriptive statistics and correlations for the proportion scores of the prior knowledge test, reading skill test, and the Session 1 and Session 2 statement score (higher score = fewer misconceptions). The mean of the Session 2 statement score was significantly higher than the Session 1 statement score, $t(89) = 21.1$, $p < 0.01$. There was a strong

correlation between prior knowledge and reading skill, and between the individual difference scores and participants' scores on the true and false statements. These correlations indicate that the more knowledgeable and skilled participants had fewer misconceptions in both Session 1 and Session 2.

Table 5: Descriptive Statistics and Correlations of Individual Differences and Misconception Statements

Variable	Mean (SD)	1	2	3
Prior Knowledge	0.66 (0.15)			
Reading Skill	0.66 (0.22)	**0.61**		
Session 1 Score	0.53 (0.50)	**0.48**	**0.43**	
Session 2 Score	0.81 (0.39)	**0.52**	**0.53**	**0.42**

Note. Bolded correlations are significant at $p < 0.01$

Question 1: Are simple statements an effective intervention for conceptual change?

Our primary research question was whether providing simple statements about misconceptions could serve as an effective intervention to prompt conceptual change. There was a strong overall effect of session (d = 0.62) such that all participants had fewer misconceptions in Session 2, indicating that the simple statements provided in Session 1 was an effective conceptual change intervention.

We further hypothesized that if the observed effect was attributable to a testing effect, the difference would be greater for the groups who saw a consistent set of items in both sessions (i.e., Groups 1 and 3 in Table 3) compared to the groups who saw an inconsistent set of items (i.e., Groups 2 and 4 in Table 3).

A linear mixed effects model was used to predict misconception test score by Session (1, 2) and Set Consistency (consistent, inconsistent), holding constant prior knowledge, reading skill, and statement set. Participant and item were entered as random variables. Table 6 shows the full model.

Table 6: Linear Mixed Effects Model Predicting Statement Score from Session and Set Consistency, holding Prior Knowledge, Reading Skill, and Statement Set Constant.

Variable	Estimate	SE	z	p
Prior Knowledge	1.03	0.32	3.19	**<0.01**
Reading Skill	0.77	0.21	3.57	**<0.01**
Statement Set	0.03	0.08	0.45	0.65
Session	1.08	0.05	20.6	**<0.01**
Consistent	-0.07	0.08	-0.87	0.38
Session * Consistent	0.74	0.08	8.74	**<0.01**

There was a significant effect of prior knowledge (d = 1.43) and reading skill (d = 1.07), as well as a significant main effect of session such that all participants had fewer misconceptions in Session 2 than in Session 1. There was also a significant interaction between session and group such that participants who saw the same set of statements in both sessions had fewer misconceptions in Session 2 compared to those who saw different sets of statements (see Figure 1).

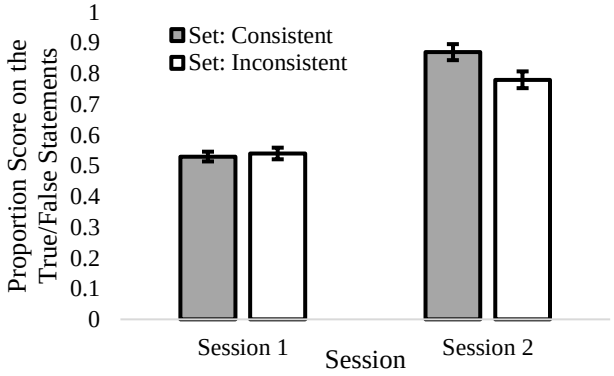

Figure 1: Proportion score on true/false statements as a function of session and set consistency.

Question 2: What is the effect of knowledge and skill on conceptual change?

The second set of analyses was conducted to examine the interactions between reading skill and session, and prior knowledge and session. It was hypothesized that simple statements would be easier to comprehend, and thus differences in misconceptions between high and low skilled participants would be attenuated in Session 2.

A linear mixed effects model was used to predict misconception test score by Session (1, 2) and reading skill, holding constant prior knowledge and statement set. Participant and item were entered as random variables. Table 7 shows the full model.

Table 7: Linear Mixed Effects Model Predicting Statement Score from Session and Reading Skill, holding Prior Knowledge and Statement Set Constant.

Variable	Estimate	SE	z	p
Prior Knowledge	1.27	0.37	3.42	**<0.01**
Statement Set	0.04	0.09	0.40	0.69
Session	0.77	0.13	5.86	**<0.01**
Reading Skill	0.33	0.26	1.29	0.19
Session * Reading Skill	1.17	0.20	5.98	**<0.01**

There was a significant interaction between session and reading skill (d = 1.48). However, the direction of the effect was such that the difference between more and less skilled participants was enhanced in Session 2 (see Figure 2). The same model was tested with prior knowledge as a predictor and reading skill as a covariate and the pattern of results was the same (d = 1.44).

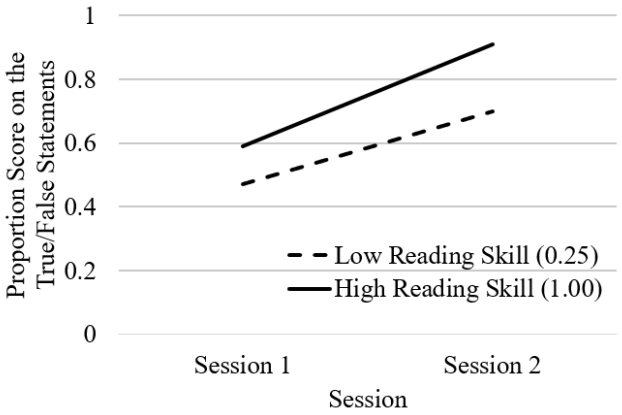

Figure 2: Estimated marginal means of high and low skill participants on the true/false statements across session.

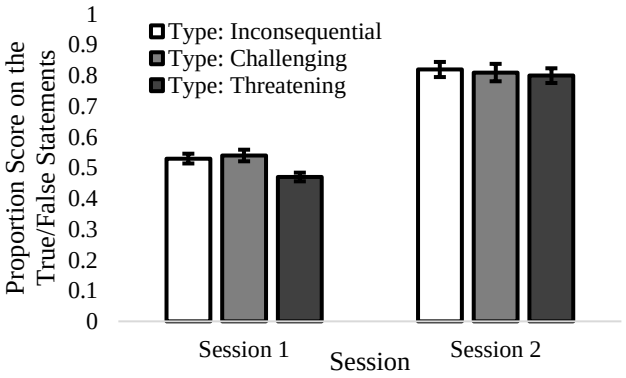

Figure 3: Proportion scores on the true/false statements as a function of session and misconception type.

Question 3: Does misconception type predict differences in item-level conceptual change?

The first analysis indicated that participants' ability to correct misconceptions was at least partially attributable to a testing effect. However, one possibility is that participants are able and willing to correct misconceptions that are inconsequential but are unwilling or unable to correct misconceptions that are identity-threatening or otherwise challenging. To address this question, a linear mixed effects model was used to predict misconception test score by Session (1, 2) and misconception type (inconsequential, challenging, threatening), holding constant prior knowledge, reading skill, and statement set. Participant and item were entered as random variables. Table 8 shows the full model.

Table 8: Linear Mixed Effects Model Predicting Statement Score from Session and Misconception Type, holding Prior Knowledge, Reading Skill, and Statement Set Constant.

Variable	Estimate	SE	z	p
Prior Knowledge	1.14	0.33	3.43	<0.01
Reading Skill	0.73	0.22	3.27	<0.01
Statement Set	0.03	0.07	0.41	0.68
Session	1.40	0.06	24.47	<0.01
Type: Challenging	0.02	0.06	0.31	0.76
Type: Threatening	-0.23	0.07	-3.27	<0.01
Session * Challenging	-0.09	0.09	-1.07	0.28
Session * Threatening	0.07	0.11	0.61	0.54

The main effects of prior knowledge, reading skill, and session reported in the first model were also observed in this second model. There was also a significant main effect of type such that participants held more misconceptions among the topics coded as threatening compared to the topics coded as inconsequential. However, there were no significant interactions (see Figure 3).

Question 4: Do participants' demographic differences predict conceptual change?

The second analysis indicated that participants' ability to correct misconceptions was not affected by the type of misconception. However, it is possible that individual differences in participants' demographics would affect conceptual change. Three additional linear mixed effects models were used to predict misconception test score by Session (1, 2) and demographic individual differences, holding constant prior knowledge, reading skill, and statement set. Participant and item were entered as random variables. One model was run for each of these demographic predictors: ethnicity, political party affiliation, and religion. None of the demographic predictors, nor interactions between demographic predictors, were significant, and the pattern of results for prior knowledge, reading skill, and session was the same as in models 1 and 2.

Discussion

This study sought to assess the extent to which simple statements are an effective intervention for conceptual change. In Session 1, participants were administered a set of 76 misconception and fact statements to rate as true or false, and given a simple statement with the correct concept after each answer. In Session 2, participants were asked to rate the misconception and fact statements as true or false again. Half of the participants were given the same set of statements as in Session 1, the other half were given the reverse set of statements. Participants were also tested on their prior knowledge and reading skill, and asked questions about their political and religious affiliation, and social media use and news sources.

Consistent with our hypotheses, there was a strong effect of session such that participants had fewer misconceptions in Session 2 than in Session 1. In addition, there was a significant interaction such that participants who saw consistent items across sessions had fewer misconceptions in Session 2 compared to participants who saw inconsistent items. These findings indicate that simple statements are an effective intervention to reduce misconceptions. In addition,

simple statements, and other interventions to correct misconceptions, are comparable to previous studies on the role of instructional feedback in learning.

Inconsistent with our hypotheses, there was a significant interaction between reading skill and session, and prior knowledge and session such that the difference between more and less skilled learners was enhanced in Session 2. This finding indicates that more skilled and knowledgeable individuals were better able to integrate the correct concept.

There was not a significant interaction of misconception type and session, which is consistent with the null hypothesis that simple statements are effective across misconception types. Likewise, demographic differences (e.g., religion) did not significantly predict conceptual change, indicating that simple statements were an effective intervention across demographic groups.

Limitations

There are three major limitations to this study, all of which may be corrected in future studies. First, while the effect of misconception type was negligible, misconception type was treated as a stable item characteristic, whereas the consequentiality of a misconception is also likely to be personal and depend on the individual. Thus, the effect of misconception type may be more apparent if it were based on participants' self-ratings of the importance of each misconception. The second limitation regards the duration of the delay between the first and second session (1-3 days) and the number of tests. Further research is needed to assess performance after longer delays and additional observation points. For example, there is some evidence that refutation or explanatory content outperforms simple statements only at more distal time points (Ecker et al., 2020), and thus this simple correctional feedback used in our study should be compared to explanatory feedback after both short and longer delays. Finally, the misconceptions tested were those that are common in the United States, and the sample population was undergraduate students. Testing the effectiveness of simple statements in more diverse populations is essential to understanding the use-cases for more complex interventions compared to simple feedback.

Finally, while simple statements were found to be an effective intervention in a laboratory setting, the natural context of the statement may play a role in individuals integrating the information. For example, the presentation of facts has been found to influence believability and engagement (Kim & Dennis, 2018). Therefore, testing the effectiveness of simple statements in different contexts is warranted.

Implications and Future Directions

The primary implication of this study is that future studies on interventions to correct misinformation and reduce misinformation *must* contain control conditions that test the efficacy of simple statements on the targeted misconceptions. The majority of the studies investigating interventions to correct misconceptions have not considered the possibility that simply telling the participant the correct information may result in strong conceptual change. At the very least, this study indicates that providing the correct statement is a necessary control condition in all future studies. To this point, an excellent example of the importance of a control condition is the recent study by Vlasceanu, Morais, and Coman (2021) who found that for most of their participants, simply stating the truth was a more effective intervention than their proposed intervention.

Finally, the strong effect of reading comprehension skill in this study suggests that the primary failure of memory is in the *integration* of the new information into memory. Past research on the role of reading skill has shown that individuals with high reading skill better use learning strategies such as elaboration and comprehension monitoring (Naumann et al., 2008). These types of strategies can enhance conceptual change by affording individuals the opportunity to identify the conflict and integrate the new information.

Enhancing individuals' ability to identify and revise misconceptions is an important research goal. However, while interventions to revise misconceptions are important, their effectiveness may be contextual, and may in most cases be less effective than simply telling the truth. Further work must be conducted to ascertain the appropriate situations to use complex interventions, and when to simply state the truth.

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