Experiment Reconstruction Reduces Fixation on Surface Details of Explanations

Abstract

Misunderstandings of science affect many lives. Novices commonly misunderstand explanations by overly relying on surface details instead of evaluating underlying logic. Prior work has found adding a patina of neuroscience leads readers towards positively assessing explanations. How might we help people better understand science explanations? A between-subjects experiment tested whether asking readers to reconstruct experiments leads them to focus more on underlying logic. Participants relied less on irrelevant surface details when reconstructing experiments. However, this did not impact their subsequent assessment of explanations. Our results suggest that reconstruction is a useful strategy for understanding explanations but is not readily transferred towards evaluating explanations.

Author Keywords
fixation; science explanations; surface features

CCS Concepts
• Applied computing → Computer-assisted instruction;

The Seduction of Details Over Structure

The knowledge-intensive and creative nature of modern life forces people to evaluate statements about domains they don’t know much about. Misunderstandings cause problems. For example, a 1993 study found that college stu-
Explanations: Information about stereotypical animals is stored in a certain way by CA3 brain cells, which have been shown to mediate memory. This makes the information more readily accessed and manipulated than information about rare animals.

Recall: Based on the explanation above, why was one type of animal easier to reason about than another?

Reconstruction: Suppose you are a scientist recreating this experiment and find similar results. Why might your subjects be better at reasoning about stereotypical animals than rare animals?

Table 1: Comprehension explanation and questions for each condition. Participants also read a description of the experiment (not shown).

This work investigates whether re-explaining a scientific finding increases understanding and reduces fixation on surface details. Learning may depend on the specific type of re-explanation. Specifically, repeating an explanation word-for-word is predicted to be less effective than drawing from personal knowledge to reconstruct an explanation [3]. In the latter, people extend the underlying logic of the explanation instead of relying on its surface details. The interpretive process of constructing personal knowledge is a form of personal or mini-C creativity [5], and orients learners towards higher levels of Bloom’s taxonomy [2].

Can Reconstruction Improve Understanding? Participants were shown a science explanation from [8]. The Reconstruction group was asked to imagine themselves as scientists reconstructing the described experiment, while the Recall group was asked to base their responses on the given text (Table 1). This study compares the effect of these two tasks on understanding science explanations that contain irrelevant neuroscience terminology.

We hypothesized that Reconstruction participants would avoid fixating on the surface details in the reconstructed explanation. We also hypothesized that Reconstruction participants would also avoid fixating on surface details in subsequent explanations, even when not explicitly instructed to reconstruct them.

Method
Participants
Undergraduates were recruited from social science courses at a California research university (n = 72, 54 female). Participants received course credit for participation and were informed that the results of their experiment would have no impact on their class performance.

Reduction on Surface Details
Redoing someone else’s work is a common learning strategy in creative disciplines, from painting to programming.
**Design**
Participants completed an online study with two tasks: **Comprehension** and **Ratings**. There are two conditions for each task, resulting in a 2 x 2 design: **Recall vs. Reconstruction** × **Without Neuroscience vs. With Neuroscience**.

**Materials**
In the **Comprehension** task, participants read a description and explanation of an experiment. The explanation included a mechanism for the experimental result and an irrelevant neuroscience surface detail. In the **Reconstruction** condition, participants were asked to imagine themselves as scientists reconstructing the experiment and answer questions about their results. Participants in the **Recall** condition, on the other hand, answered questions about the text itself (Table 1).

In the **Rating** task, participants rated the quality of explanations copied from [8] (Table 2). Each explanation either proposed a logical mechanism or provided a circular re-statement of a psychology finding. Each subject rated 4 logical and 4 circular explanations in a random order. In the **With Neuroscience** condition, irrelevant neuroscience information was added to every explanation.

**Measures**
Independent variables are the **Comprehension** task questions (**Recall** vs. **Reconstruction**), explanation content (**With Neuro** vs. **Without Neuro**), and explanation quality (logical vs. circular).

Dependent variables are the **Comprehension** responses and numeric ratings of explanation quality ranging from +3 (good) to -3 (bad).

One independent rater coded each **Comprehension** response on three binary scales: **Neuro**, **True**, and **Guessed**.

**Results**
**Reconstruction Participants Generate Alternative Mechanisms**
In the **Comprehension** task, **Recall** participants relied on the explanation's text. When asked why an experimental finding occurred, they often included the explanation's provided mechanism but also its irrelevant neuroscience information (Figure 1). Compared to **Recall**, **Reconstruction** participants were less likely to include the explanation's mechanism and neuroscience information (True: \(t(61.0) = 4.19, p < 0.01\); **Neuro**: \(t(66.7) = 5.45, p < 0.01\)). Instead, **Reconstruction** participants generated alternative mechanisms more often than **Recall** (Guessed: \(t(86.0) = -4.79, p < 0.01\)). This provides evidence that reconstructing an explanation encourages creative problem-solving.
Contrary to our hypothesis, participants in both conditions rated circular explanations higher quality when explanations contained neuroscience information (a). Participants rated circular explanations without neuroscience lower quality than logical explanations (b).

**Neuroscience Detail Increases Ratings of Circular Explanations**
Contrary to our hypothesis, participants in both conditions rated circular explanations with neuroscience higher quality than circular explanations without neuroscience (*Recall*: $t(125.6) = -2.10, p < 0.05$; *Reconstruction*: $t(157.2) = -3.233, p < 0.01$) (Figure 2a). In addition, there was no significant difference between *Recall* and *Reconstruction* for ratings of circular explanations with neuroscience ($t(121.8) = -1.8, p > 0.05$). These patterns are consistent with prior work that did not include a task before ratings, suggesting that neither *Recall* nor *Reconstruction* mitigated the positive bias caused by neuroscience surface details.

**Without Neuroscience Detail, Logical Explanations Rated Higher Quality**
When explanations did not include neuroscience, participants rated logical explanations higher quality than circular explanations (*Recall*: $t(119.1) = 5.69, p < 0.01$; *Reconstruction*: $t(180.4) = 3.22, p < 0.01$) (Figure 2b). This is also consistent with prior work, suggesting that participants perceived a difference between logical and circular explanations when neuroscience was not included.

**Discussion**
*Reconstruction Reduced Fixation on Irrelevant Surface Details*
Despite the inclusion of an irrelevant neuroscience surface detail in the explanation, *Reconstruction* participants seldom used this detail when reconstructing the explanation. In fact, *Reconstruction* participants proposed alternative mechanisms instead of referencing either neuroscience detail or original mechanism in their explanations. One interpretation is that these participants ignored the text entirely. If this was the case, the proposed mechanisms should be irrelevant or inconsistent. Most *Reconstruction* participants, however, proposed relevant mechanisms that accounted for the specific experimental results discussed in the text. Some proposed mechanisms referenced the original explanation and elaborated on it, demonstrating both knowledge of and ability to extend the text’s structure. While *Recall* responses were often word-for-word copies of the text, *Reconstruction* responses proposed a variety of distinct mechanisms. For example, one *Reconstruction* participant suggested a mechanism based on confidence:

“It may be possible that not only is this information easier to access, but participants are more confident because of their familiarity with stereotypical birds.”

Another suggested a mechanism based on prior knowledge:
“people are more likely to have previous knowledge on stereotypical birds which makes it easier to understand the new information.”

This finding suggests that reconstructing an explanation reduces fixation and encourages flexible problem-solving.

The Challenge of Transfer

Reconstruction participants used irrelevant neuroscience details as an indication of quality in the Ratings task despite avoiding the same details in the Comprehension task. Although the two tasks shared the same explanation format, participants might have perceived that the tasks were unrelated—participants might not have transferred strategies learned in one task to the other. This finding highlights the challenge of transfer even between activities that appear similar.

Conclusion

We examined whether reconstructing an explanation improved understanding of science explanations compared to a recall activity. Participants reconstructing an experiment fixated less on surface details and showed more flexibility in problem-solving. When evaluating explanations, however, participants in both conditions were still influenced by irrelevant neuroscience surface features. Although reconstruction appears to be an effective strategy for understanding explanations, participants do not readily transfer this strategy towards evaluating explanations.

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References


