
Experiment Reconstruction Reduces Fixation on Surface Details of Explanations

Samuel Lau

Design Lab, UC San Diego
La Jolla, CA 92093
lau@ucsd.edu

Scott Klemmer

Design Lab, UC San Diego
La Jolla, CA 92093
srk@ucsd.edu

Tricia Ngoon

Design Lab, UC San Diego
La Jolla, CA 92093
tngoan@ucsd.edu

Vineet Pandey

Design Lab, UC San Diego
La Jolla, CA 92093
vipandey@ucsd.edu

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-

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Explanation: 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).

dents momentarily performed better on spatial reasoning when listening to Mozart [6]. This “Mozart Effect” experienced widespread acceptance. Florida passed a bill requiring day care programs to play classical music to infants, Georgia budgeted \$105,000 to distribute classical music to newborns, and “Mozart Effect” products sold millions of copies [1]. The Mozart Effect paper only reported a temporary increase in spatial reasoning, yet numerous news articles claimed that Mozart makes people permanently “smarter”. Compelling surface details like Mozart’s name can overshadow the logic within an explanation.

Fixation on Surface Details Prevents Understanding

Most people are science novices; despite the presence of scientific findings in the news, most people lack the skills to interpret or evaluate these findings. Novices focus primarily on surface details of a situation: the literal objects, concepts, or entities explicitly described [4]. As the Mozart Effect demonstrates, surface details act as fixating cues that can result in misunderstandings.

One prior study presented people with logically coherent and illogically circular science explanations. People generally perceived logical explanations as more satisfying than illogical ones. However, when irrelevant brain-related terminology was added to the explanations, novices in neuroscience rated illogical explanations more satisfying [8].

Such fixation hinders creative problem-solving by preventing broad search of a solution space [7]. When understanding a science explanation, fixation on surface details like neuroscience terminology may discourage people from examining the explanation’s logic.

Reducing Fixation on Surface Details

Redoing someone else’s work is a common learning strategy in creative disciplines, from painting to programming.

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.

Description (excerpt): The researchers discovered that words spoken soon after a presented target word were words that sounded like the target, while words spoken later were words that had a similar meaning to the target.

Rate the quality of the following explanation:

Patterns of brain activation in these subjects lead researchers to conclude that this happens because Broca's area, a part of the brain's language system, associates two different types of words with the target word at two different times.

Table 2: Example of a circular explanation with neuroscience in the Ratings task.

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* x *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 restatement 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*.

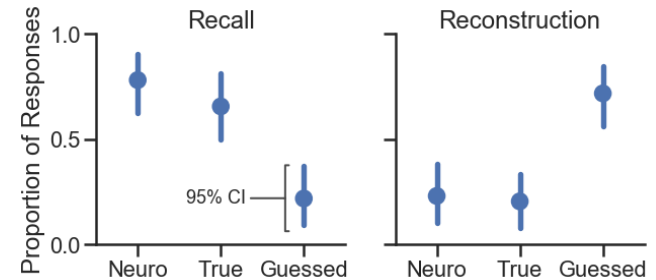


Figure 1: In the *Comprehension* task, *Recall* participants utilize irrelevant neuroscience information, while *Reconstruction* participants propose alternative mechanisms without relying on neuroscience information.

A response was marked as *Neuro* if it referenced the irrelevant neuroscience information from the original explanation. A response was marked as *True* if it referenced the mechanism provided by the original explanation. Finally, a response was marked as *Guessed* if it proposed an alternative mechanism not directly present in the original explanation.

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: $t(68.0) = -4.79$, $p < 0.01$). This provides evidence that reconstructing an explanation encourages creative problem-solving.

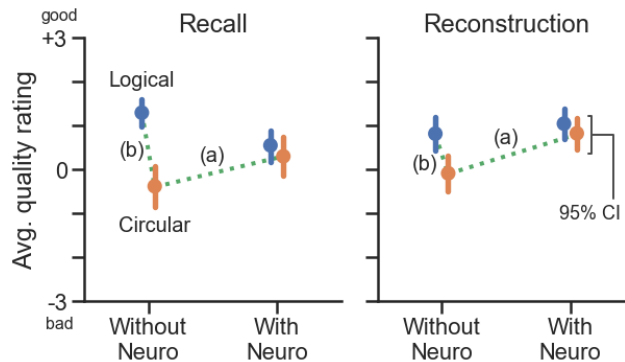


Figure 2: Contrary to our hypothesis, participants in both conditions rated circular explanations higher quality when explanations contained neuroscience information (a). Participants rated circular explanations without neuroscience lower quality than logical explanations (b).

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.

Acknowledgments

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