Supplementary Online Materials For: Broad effects of shallow understanding: Explaining an unrelated phenomenon exposes the illusion of explanatory depth

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# Supplemental Analyses

## Experiment One

**Confirmatory Analyses**

We deviated somewhat from the preregistration protocol.[[1]](#footnote-1) We analyzed the effect of (attempted) explanation on self-reported understanding in a linear mixed model with fixed effects of Phenomenon Judged, Time, and Phenomenon Explained, and random effects of Phenomenon Judged nested within participants. We effect-coded Time. We also effect-coded Phenomenon Explained by contrasting whenever the Phenomenon Judged matched the Phenomenon Explained (e.g., rated zipper and explained zipper) with whenever the Phenomenon Judged did not match the Phenomenon Explained (e.g., rated zipper and explained sewing machine). All fixed effect predictors were allowed to interact, and the random effect predictors were allowed to interact.

We found a main effect of Time: understanding ratings significantly decreased from pre- to post-explanation, *F*(1, 1428) = 278.48, *p* < .001. Notably the Time by Phenomenon Explained interaction was not significant, *F*(1, 1097), *p* = .067. This suggests that the reduction in understanding of, for example, a zipper (device) was similar when a zipper was explained and when something other than a zipper was explained. However, as can be seen in Figure 1 in the main text, it could be that explaining something other than a zipper leads to an even greater reduction in understanding of a zipper. We caution against such an interpretation. This is because understanding ratings for some items appear to decrease more when the same object is explained, and others decrease more when something else is explained. This can be observed in Figure 2 in the main text, which displays the mean understanding ratings for each Phenomenon Rated by Phenomenon Explained.

**Similarity Analyses**

In Study 1, we collected similarity ratings on a 1 (Not at all similar) to 5 (Extremely similar) scale for each possible pair of devices. This summed to 15 ratings in total. Figures S1a-f below display 6 plots that show for each device, the average similarity (with accompanying 95% confidence intervals) with each other device. These figures demonstrate that similarity does not mediate the effect of reducing the estimate of understanding of one device after explaining a different one. For instance, figure S1a shows that the sewing machine was rated as more similar to a zipper than any other device compared. Yet, consulting Figure 2 of the main manuscript, the reduction in knowledge of a zipper when a sewing machine was explained was highly similar to the reduction in knowledge of a zipper when any other item was explained. Similarly, the reduction in knowledge of a sewing machine when a zipper was explained was highly similar to the reduction in knowledge of a sewing machine when any other item was explained. This should illustrate that similarity between devices cannot predict the extent to which a person reduces their estimate of one device after explaining a different one.

Chart, line chart

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Figure S1a. Average similarity ratings between a zipper and a given object. Error bars are 95% within-subject confidence intervals.

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Figure S1b. Average similarity ratings between a speedometer and a given object. Error bars are 95% within-subject confidence intervals.

A picture containing text, antenna

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Figure S2c.. Average similarity ratings between a sewing machine and a given object. Error bars are 95% within-subject confidence intervals.

Chart

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Figure S3d. Average similarity ratings between a quartz watch and a given object. Error bars are 95% within-subject confidence intervals.

Chart

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Figure S4e. Average similarity ratings between a helicopter and a given object. Error bars are 95% within-subject confidence intervals.

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Figure S5f. Average similarity ratings between a piano and a given object. Error bars are 95% within-subject confidence intervals.

This is further supported by exploratory analyses. We computed a linear mixed model with Similarity Rating as the dependent variable and Pair as the fixed effect predictor variable nested within a random participant intercept. Pairs that were significantly more (or less) similar relative to the similarity ratings of the pair Speedometer-Zipper are indicated in Table S1 below. These correlations confirm the pattern noted in the above paragraph. For instance, the sewing machine is considered much more similar to a Zipper than it is to any of the other devices yet the reduction in a Sewing Machine after having explained a zipper looks is similar to the when the rest of the items are explained. Similarly, the reduction in zipper after explaining a Sewing Machine is similar to the when the rest of the items are explained.

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| Table S1. Correlations of Similarity ratings between device pairs, statistically compared to the Speedometer-Zipper pair. | | | | | | |
|  | Helicopter | Piano | Quartz Watch | Sewing Machine | Speedometer | Zipper |
| Helicopter | ― | -.06 | .21\* | .25\* | .46\* | -.06 |
| Piano |  | ― | .25\* | .29\* | .07 | .07 |
| Quartz Watch |  |  | ― | .21\* | .67\* | .06 |
| Sewing Machine |  |  |  | ― | .19\* | .75\* |
| Speedometer |  |  |  |  | ― | NA |
| Zipper |  |  |  |  |  | ― |

*Note*. An asterix indicates that the correlation is significantly different (at the .001 level) from the correlation between the similarity ratings of the Zipper and Speedometer pair.

## Experiment Two

**Confirmatory Analyses**

We analyzed the effect of explaining on self-reported understanding in a linear mixed model with fixed effects of Phenomenon Judged, Time, and Phenomenon Explained, and random effects of Phenomenon Judged nested within participants. We effect-coded Time. We also effect-coded Phenomenon Explained by contrasting whenever the Phenomenon Judged matched the Phenomenon Explained with whenever the Phenomenon Judged did not match the Phenomenon Explained. All fixed effect predictors were allowed to interact, and the random effect predictors were allowed to interact.

We replicated the findings of Experiment 1. We found a main effect of Time: understanding ratings significantly decreased from pre- to post-explanation, *F*(1, 924) = 145.83, *p* < .001. Notably the Time by Phenomenon Explained interaction was not significant, *F*(1, 924) = 0.93, *p* = .335. This suggests that the reduction in understanding of, for example, a zipper did not differ between whether a zipper was explained or something other than a zipper was explained.

We then compared the reduction in understanding between providing an explanation (experimental condition) and not providing an explanation (control condition) using a similar mixed effect model in which Writing Condition replaced Phenomenon Explained as a fixed effect. We found a significant Time by Writing Condition interaction, *F*(1, 1956) = 29.94, *p* < .001.[[2]](#footnote-2) As Figure 1 shows, people reported knowing less about devices after attempting to explain how a device works compared to not attempting to explain how a device works. However, post-hoc tests revealed that even in the no-explanation control condition, people reported knowing less about devices when understanding was re-assessed, *z* = 6.41, *p* < .001. This suggests that some portion of the reduction in understanding is not attributable to having explained something.

## Experiment Three

**Confirmatory Analyses**

We analyzed the effect of explaining on self-reported understanding in a linear mixed model with fixed effects of Phenomenon Judged, Time, and Phenomenon Explained, and random effects of Phenomenon Judged nested within participants. We effect-coded Time. We also effect-coded Phenomenon Explained by contrasting whenever the Phenomenon Judged matched the Phenomenon Explained with whenever the Phenomenon Judged did not match the Phenomenon Explained. All fixed effect predictors were allowed to interact, and the random effect predictors were allowed to interact.

We first analyzed the reduction in understanding when an explanation was provided (not including participants in the control condition). We found a main effect of Time: understanding ratings significantly decreased from pre- to post-explanation, *F*(1, 690) = 87.33, *p* < .001. We also found a significant Time by Phenomenon Explained interaction, *F*(1, 690) = 4.52, *p* = .049. As Figure 1 suggests, explaining something else may lead to a greater reduction in understanding, however, as in Experiment 1 we suggest this finding should be interpreted with caution. This is reflected in the non-significant (what some might term “marginal”) three-way interaction between Time, Phenomenon Explained, and Phenomenon rated, *F*(1, 690) = 2.09, *p* = .065. We computed exploratory post-hoc contrasts for each Phenomenon Rated by Phenomenon Explained across Time, correcting for multiple comparisons. We found the greatest difference in contrast estimates for the phenomena “Snow” and “Speedometer”. In these cases, when the phenomenon itself was explained, people did not report understanding the phenomenon significantly less (Snow: *B* = -0.22, *p* = .315; Speedometer: *B* = -0.10, *p* = .673) and the trend of the data suggests somewhat greater understanding of the phenomenon. However, when a different phenomenon was explained, people reported understanding Snow and Speedometer significantly more (Snow: *B* = 0.47, *p* < .001; Speedometer: *B* = 0.44, *p* < .001). People behaved a bit differently for the other phenomena (Earthquake, Immigration, Trade, Zipper). In these cases, participants always reported a nominally lower understanding of the phenomenon regardless of whether they explained the same phenomenon or a different one.

We then compared the reduction in understanding between providing an explanation (experimental condition) and not providing an explanation (control condition) using a similar mixed effect model in which Writing Condition replaced Phenomenon Explained as a fixed effect. We found a significant Time by Writing Condition interaction, *F*(1, 1572) = 24.22, *p* < .001.[[3]](#footnote-3) As Figure 1 shows, people reported knowing less about how phenomena occur after attempting to explain how they work, and this reduction was greater than after not attempting to explain how they work. However, post-hoc tests revealed that people still reported knowing less about phenomena even without attempting to explain how they work, *z* = 4.74, *p* < .001. Consistent with Experiment 2, this suggests that some portion of the reduction in understanding is not attributable to having explained something.

1. We incorrectly preregistered a model that contained Time as a random effect. Time should only be entered as a fixed effect and so we report a model not including Time as a random effect. We also preregistered a model that effect-coded Phenomenon Judged. This was incorrect and so we report a model where Phenomenon Judged is not effect-coded. This applies to all linear mixed model analyses reported in this supplement. [↑](#footnote-ref-1)
2. A less complex model with Understanding Rating entered as dependent variable and Time and Writing Condition entered as predictors (in an Analysis of Variance) revealed a non-significant Time by Writing Condition interaction, *F*(1, 3932) = 3.72, *p* = .054. [↑](#footnote-ref-2)
3. A less complex model with Understanding Rating entered as dependent variable and Time and Writing Condition entered as predictors (in an Analysis of Variance) revealed a non-significant Time by Writing Condition interaction, *F*(1, 3164) = 3.15, *p* = .076. [↑](#footnote-ref-3)