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Abstract

Although analogical examples can support better understanding of new science concepts, when analogies are included superficially and without explanation they may have unintended negative effects. In this study, simple inclusion of analogies greatly increased the perceived familiarity and predicted understanding of geology concepts. Higher judgements of familiarity and predicted understanding could produce illusions of understanding when reading texts about these concepts.

Theoretical Background

Readers tend to be poor at gauging how well they have understood what they have read in expository science texts (i.e., they have poor metacomprehension accuracy; Griffin, Mielicki, & Wiley, 2019). Specifically, people experience illusions of understanding for explanations of scientific phenomena (Keil, 2006). Textbooks in Geology and other sciences often include analogies intended to help learning by connecting new concepts to something already familiar to students (Jee et al., 2010). That familiarity with the source objects in the analogies may increase students' expectations and judgements about how well they will understand the target science concepts, even when an analogy is presented superficially. This could lead to overconfidence (Jaeger & Wiley, 2015) and poor metacomprehension accuracy.

Method

Participants

Complete data was obtained from 76 UIC students (self-reported: 74% female, mean age of 19.1). A slight majority (58%) spoke another language in addition to English, 26.3% viewed themselves as ESL students, but only 5.3% reported that their non-English language was their most proficient language.

Materials and Procedure

A total of 28 analogies were taken from commonly used textbooks in Introductory Geology courses. All analogies included some type of non-geology object or event that the textbook related to a particular key causal process in geology.

Students were first asked to rate their familiarity with just the non-geology objects or events used in the analogies. Some objects were described with a single word (e.g., "blankets"), while others were events were described in phrases with up to 9 words (e.g., "pulling a piece of chewing gum between your fingers"). Ratings were made on a 1 (not at all) to 5 (extremely familiar) scale.

After rating the objects, students were presented with the 28 sentences that each mentioned a geology concept. For half of the students, the sentence included the analogy as it appeared in the textbooks, with expressions that connected the geology concept to the source objects/events using words such as "like" or "similar to". For the other half of students, the analogy was not included. Moreover, the fact that some sentences might contain an analogy was never mentioned in the instructions or any point prior in the study. All students were asked to complete ratings on a 5-point scale of how familiar they were with each concept, and how much they thought they would understand from a short text about the concept.

Results

Familiarity with the Source Objects. Familiarity ratings for the everyday objects themselves were above the midpoint of the scale (M = 3.30, SD = .65). Two standard deviations covered the range from ratings of 1.90 to 4.5, indicating that there was variability between students in how familiar these objects were. Ratings did not differ between conditions $t(74) = 1.40$ $p = .17$), which was expected since both conditions rated the same objects as their first task.

There was also a great deal of variability in familiarity for the 28 different objects. For 5 of the objects, a maximum possible rating of 5 was given by a majority of students (blankets, a sponge soaking up water, floating ice cubes, draping a blanket over a chair, opening a bottle of soda). In contrast, 2 of the objects were given the lowest possible rating by most students (adding ballast to a submarine, using a giant rasp). Another 4 objects were rated below the midpoint of the scale by a majority of students (a ship sinking as it takes on cargo, the deck of a ship rising as cargo is removed, the pattern of spokes on a wheel, pressing dough in a vise).

Ratings for Geology Concepts with or without Analogies. When students rated the geology concepts without the analogy, their familiarity ratings were low (below the midpoint of the scale) (M = 2.03, SD = .69). A paired-samples t-test showed that students were significantly more familiar with the source objects than the geology concepts, $t(38)= 10.50$, $p < .001$, $d = 1.68$. However, when the geology concept was presented with the analogy, familiarity ratings were significantly higher than when geology concepts were presented without the analogy: M = 2.90, SD = .99; $t(74)= 3.37$, $p < .001$, $d = .77$.

An independent-samples t-test showed that judgements of understanding were also significantly greater when concepts were presented with analogies (M = 3.24, SD = .82) than without (M = 2.62, SD = .78, $t(74)= 4.46$, $p < .001$, $d = 1.02$). As evidenced by the Cohens d values, these effects were large. Also, the standard deviations indicate there was substantial variability in ratings, and that variability increased when the analogies were included. Examining the data more closely, this increase in range is because students rarely gave ratings of 4 or 5 (on a 5-point scale) unless the analogy was included with the geology concept. In addition, between-student variability in ratings of familiarity of the source objects predicted judgements of understanding for the geology concepts, but only when the related analogy was included ($r = .53$, $p < .001$) versus not included ($r = .25$, $p = .13$).

Discussion

Analogies included in widely adopted geoscience textbooks vary a great deal in how familiar students are with the source object or event used in the analogy. This is important because the purpose of analogies is to connect a novel concept (i.e., the geology concept) to something that students are supposedly more familiar with. Familiarity ratings for these source objects were, on average, 2 standard deviations higher than familiarity for the geology concepts presented without analogies. However, several of the source objects were rated very low and even lower than the geology concepts. Also, there was high variability between students in their familiarity with the various objects, implying that the analogies may not benefit all students equally. Students with less familiarity with the source objects gave lower expected judgements of understanding for the geology concepts that included the related analogies.

Consistent with predictions, inclusion of analogies greatly increased the perceived familiarity and predicted understanding of related texts about the geology concepts. This could produce illusions of understanding that undermine metacomprehension. This is especially likely if the analogies do not

actually improve understanding, such as when the analogy is presented only superficially and not fully mapped onto the geology concept. These hypotheses are being tested in subsequent studies.

Author Note

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References

Griffin, T. D., Mielicki, M. K., & Wiley, J. (2019). Improving students' metacomprehension accuracy. In J. Dunlosky & K. Rawson (Eds.), *Cambridge handbook of cognition and education* (pp. 619-646). New York, NY: Cambridge University Press.

Jaeger, A. J. & Wiley, J. (2015). Reading an analogy can cause the illusion of comprehension. *Discourse Processes, 52*, 376-405.

Jee, B. D., Uttal, D. H., Gentner, D., Manduca, C., Shipley, T., Sageman, B., Ormand, C. J., & Tikoff, B. (2010). Analogical thinking in geoscience education. *Journal of Geoscience Education, 58*, 2–13.

Keil, F. C. (2006)/ Explanation and understanding. *Annual Review of Psychology. 57,* 227-54.