Speak Up and Listen! Understanding Instructional Animations Through Explanations

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Abstract. This study investigated learning from an instructional animation when learners are required to construct mental representations from an animation's functional relations through self-explaining or via instructional explanations (i.e. narration). In addition, it is investigated whether or not these explanations need to be supported by cues that guide learners' attention. Psychology undergraduates studied a cued or an uncued animation of the cardiovascular system with or without accompanying narration and while self-explaining or not. Subsequently, participants were given retention, inference, and transfer tests. Results showed better learning outcomes with cued than with uncued animations. Furthermore, higher inference scores were observed when narrations accompanied the animation, but no differences were found between the self-explaining and narration conditions on retention and transfer. It is concluded that combining cues with explanations is required for improving learning from animations, irrespective of whether or not the explanations are self-generated.

Keywords: animation; cueing; self-explaining, instructional explanation

Recently, De Koning, Tabbers, Rikers, and Paas (in press) showed that prompting learners to self-explain while studying a cued animation resulted in more correct inferences and higher transfer performances than asking learners to generate self-explanations without cues or studying the animation without self-explanations. These findings suggest that learners can properly extract a dynamic system's functional relations if they are stimulated to generate self-explanations, provided that they have sufficient working memory resources to engage in generative processing due to cues. Moreover, cueing alone seems insufficient to improve learning from animations.

Even though self-explaining might be beneficial for learning, it may not ensure that all functional relations are extracted accurately, which may leave learners with incomplete or incorrect knowledge (Renkl, 2002). For example, novices might not possess adequate background knowledge to provide high-quality self-explanations. Therefore, providing the functional relations to learners as a narrated explanation may be more effective at supporting mental model construction (cf. Wittwer & Renkl, 2008). According to Renkl (2002), instructional explanations contain correct information and can serve as an external information source that provides help to overcome problems in understanding. These characteristics might provide advantages over self-explaining when learning from animations. Nevertheless, instructional explanations also might have some disadvantages (Wittwer & Renkl, 2008). For example, if mental representations can be accurately constructed from the information provided in narrations, learners do not have to integrate animation and narration to gain understanding.

In this study, we investigated whether *providing* instructional explanations through self-explaining and *receiving* instructional explanations via narration supports learners to process animations more deeply. Moreover, it is studied whether such explanations need to be supported by attention-directing cues. We expected a main effect of cueing, indicating that learners who studied a cued animation with explanations would have higher performances on retention, inference and transfer tests than learners studying an uncued animation with explanations. We also hypothesized that learners who studied the animation with accompanying narrations would have higher performances on inference, retention, and transfer tests than learners who generated self-explanations during the animation.

Method

Seventy-six psychology students (20 male; age: M = 20.38 years, SD = 2.36) from Erasmus University Rotterdam participated in a study with the factors cueing (yes vs. no) and instructional strategy (self-explanation vs. instructional explanation). They were randomly assigned to one of four conditions: cueing with self-explaining, cueing with instructional explanations, no-cueing with self-explaining condition, and no-cueing with instructional explanations.

An animation of the cardiovascular system, depicting the dynamics of the system's five main subsystems (e.g., valves) was used. In the cued animation, each subsystem was highlighted consecutively by slightly darkening all elements in the animation except for the cued part, whereas in the uncued animation no cues were present. Participants were first tested for their prior knowledge. They then completed a practice exercise in order to familiarize themselves with the upcoming learning task. Subsequently, participants studied a labeled diagram to learn the names of the main structures of the cardiovascular system. Then, participants studied the animation of the cardiovascular system. The animation was system-paced and lasted about 5 minutes. In the self-explanation conditions, participants explained aloud the functioning of the cardiovascular system while they viewed the animation. An experimenter prompted participants when they paused for more than 5 seconds. Self-explaining did not increase time on task. All self-explanations were recorded with a tape-recorder. Participants in the instructional explanation conditions watched the animation silently while listening to a narration accompanying the animation. The narration delivered functional information explaining the functioning of the cardiovascular system, but comprised little structural and temporal information. Thereafter, participants answered 32 multiple choice retention items (asking about structure and parts of the animation), 14 open-ended inference items (asking about functional relations), and five open-ended transfer items (asking participants to reason about the whole system). To measure participants' cognitive load after the learning task and each test task, a 9-point mental effort rating scale was used.

Results

A MANOVA on retention, inference, and transfer scores with cueing and instructional strategy as between-participants factors showed a significant main effect for cueing (Wilks' λ = 0.62, F (3,67) = 13.51, $p < .05$, partial $\eta 2$ = .377), and instructional strategy (Wilks' λ = 0.89, F (3,67) = 2.77, $p < .05$, partial $\eta 2$ = .110, but no significant interaction (Wilks' λ = 0.95, F (3,67) = 1.09, $p > .05$).

Follow up ANOVAs, revealed a significant cueing-effect on retention (F (1,69) = 10.67, MSE = 15.05, $p < .05$, partial $\eta 2$ = .134), indicating higher numbers of correctly answered retention questions in the cued (M = 18.32, SD = 3.97) than in the uncued conditions (M = 15.42, SD = 3.81). The inference-test data also yielded a significant main effect of cueing (F (1,69) = 31.33, MSE = 14.61, $p <$ .05, partial $\eta 2$ = .312), with higher numbers of correct inferences for the cued (M = 15.46, SD = 3.35) than for the uncued conditions (M = 10.53, SD = 4.51). The transfer-test data showed a significant effect of cueing with significantly higher scores for the cued (M = 8.14, SD = 3.14) than the uncued conditions (M = 4.86, SD = 2.40) (F (1,69) = 24.51, MSE = 8.00, $p < .05$, partial $\eta 2$ = .262).

The ANOVA results concerning instructional strategy revealed a significant effect on the inference test (F (1,69) = 5.31, MSE = 14.61, $p < .05$, partial $\eta 2$ = .071), with the instructional explanation conditions (M = 13.97, SD = 4.33) providing significantly more correct inferences than the self-explaining conditions (M =13.03, SD = 4.65). However, no significant main effects of instructional strategy were found on the retention and transfer tests (both Fs (1,69) < 1, *ns*).

For the mental effort measures, no significant differences on either cueing (Wilks' λ = 0.90, F (4,66) = 1.80, p > .05) or instructional strategy (Wilks' λ = 0.95, F < 1, *ns*), nor a significant cueing × instructional strategy interaction was found (Wilks' λ = 0.93, F (4,66) = 1.22, p > .05).

An analysis of the self-explanation data showed that cueing significantly influenced learners' self-explanation activity (Wilks' λ = 0.36, F (7,27) = 7.01, p < .05). Participants in the cued self-explanation condition generated significantly more meaningful types of self-explanations than the uncued self-explanation condition. The cued self-explainers generated on average 11.23 correct inferences whereas the uncued self-explainers generated on average 5.42 inferences. The total number of inferences derived from the animation through self-explaining appears to be at best less than half of the 23 inferences that the learners could infer or received in the instructional explanation condition.

Discussion

Our results suggest that cued animations with explanations were more effective at improving learners' understanding than uncued animations with explanations. This is the case when learners actively generate self-explanations (also see De Koning et al., in press) as well as when they receive instructional explanations accompanying a cued animation. Moreover, cueing in animations appears to influence learning outcomes to a similar extent for generating and receiving explanations.

However, learners receiving instructional explanations during the animation had higher inference test performance than those who generated self-explanations. Learners in the instructional explanation conditions generated approximately twice as much inferences than self-explainers, indicating that self-explainers were unable to extract the required functional knowledge from the animation. Despite the fact that narration groups received all 23 correct inferences whereas the self-explanation group had only generated approximately 11 inferences during learning, it is striking that in the cued conditions the inference test scores for these groups are not far apart. Moreover, in contrast to our predictions, the transfer test scores did not differ between the self-explanation and narration conditions. So, despite the incompleteness of self-explaining, learners who self-explained seemed well able to generate a reasonable number of inferences and to perform almost as well as the narration groups on the transfer test. Therefore, it might be suggested that providing correct functional information to learners via narration accompanying an animation does not guarantee that learners construct far more accurate mental representations from dynamic systems than via self-explanations.

To conclude, this study suggests that learning from animations requires learner-generated (i.e., self-explaining) or externally-generated explanations (i.e., narration) to be combined with attention-directing cues. Moreover, the results suggest that in cued animations correct and accurate information via narrations may not pay off against the flexibility and generative nature of self-explaining.

Referencces

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