Does the Segmenting Principle Counteract the Modality Principle in Multimedia Instruction?

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Abstract

This study investigated the segmenting and modality principles in instructional animation. Two segmentation conditions (cued recall vs. pause only) were presented in combination with modality principle. The results showed that the significant effect was found in segmentation condition whereas the modality effect was not significant. The groups with cued recall between segments outperformed pause-only groups on both retention and transfer tests regardless of the modality of text. The findings imply that a stimulus (e.g., cued recall) would be more effective than only pauses between segments.

Introduction

Instructional animation is a dynamic visual representation that vividly presents complex events, and it is increasingly used to show motion or procedure in instructional settings (Lin & Atkinson, 2011; Mayer & Chandler, 2001). However, instructional animation is not always effective comparing static visuals, because dynamic information may impose greater cognitive processing demands because various objects and events are replaced with other information during the animation (Hegarty, Kriz, & Cate, 2003; Mayer, Hegarty, Mayer, & Campbell, 2005; Spanjers, Wouters, van Gog, & van Merriënboer, 2011; Tversky, Bauer-Morrison, & Bétrancourt, 2002).
In order to overcome cognitive overload with transient information in animation, modality and segmenting principles along with other multimedia principles have been proposed (e.g., Ayres & Paas, 2007; Hasler, Kersten, & Sweller, 2007; Mayer, 2009). The modality principle refers that animation with spoken-text (i.e., narration) is more effective than animation with written-text (i.e., on-screen text), because negative consequences of split-attention (Mayer, 2009; Mousavi, Low, & Sweller, 1995). Meanwhile, the segmenting principle has been proposed to reduce cognitive overload by presenting animation in pieces (i.e., segments) (Mayer, 2009; Spanjers et al., 2011).

Most segmentation studies have provide pauses between segments with either learner-paced or system-controlled time so that learners can have more time to process information presented in the previous segment (e.g., Hasler, Kersten, & Sweller, 2007; Mayer & Chandler, 2001; Mayer, Dow, & Mayer, 2003). However, there have been little studies on a meaningful stimulus rather than pauses between segments. Moreover, the effect of modality principles has not been investigated with segmented animation. Therefore, this study investigated (a) whether segmenting with cued recall was more effective than segmenting with pause only, and (b) whether animation with spoken text was still more effective than written text in segmented condition.

Theoretical Background

Modality principle

Proponents of the modality principle argue that if words are presented visually (e.g., on-screen text), then the visual subsystem of working memory can become overloaded based on Baddeley’s model (1992) that states that there are two sub-systems (one for visual information and another for verbal information) in working memory. On the other hand, spoken text allows more resources to be allocated to learning by activating verbal processing system. The modality effect has been explained with the cognitive load theory (Paas, Renkl & Sweller, 2003; Sweller, 2005) and the cognitive theory of multimedia learning (Mayer, 2005, 2009). However, some recent studies have found a reverse modality effect in which written text was superior to spoken text with learner control over the pacing of instruction (e.g., Cheon, Crooks, Inan, Flores, & Ari, 2011; Crooks, Cheon, Inan, Ari, & Flores, 2012; Ginns, 2005; Schnotz, 2005; Tabbers, Martens, & van Merriënboer, 2004). Hence, as Mayer (2009) stated, the modality effect would be more applicable when a multimedia is fast-paced with familiar words.

Segmenting principle

Since working memory has a limited capacity (Baddeley, 1992) and time constraint (Barrouillet & Camos, 2007), continuous multimedia (e.g., animation) causes working memory to be overwhelmed especially when material is complex or fast-paced. For example, while learners are integrating incoming words and pictures with other information, there will be little capacity left to process following materials (Mayer, 2009; Sweller, 2010). In other words, the transient dynamic information induces high extraneous cognitive load (Ayres & Paas, 2007; Mayer & Chandler, 2001; Mayer & Moreno, 2003). Thus segmentation can reduce the negative load by dividing whole unit into smaller segments. For example, pauses between segments provide learners sufficient time to process information previously presented. In addition, the segments can provide chunking information as a temporal cue that enhance the understanding of the structure of the procedure with sub events (Spanjers, van Gog, & van Merriënboer, 2010).

Most segmentation research used pauses between segments of instructional multimedia, and the findings were consistent in both learner controlled and system controlled pauses. Under learner controlled pause condition, learners were allowed to pause at their own rate with only one option to move the next segment (Hasler, Kersten, & Sweller, 2007; Mayer & Chandler, 2001; Moreno, 2007) or two options to repeat the previous segment or move to the next one (Boucheix & Guignard, 2005; Mayer, Dow, & Mayer, 2003). On the other hand, Spanjers et al. (2011) limited pauses to two seconds as a system controlled condition. All those studies found that segmented learning environment performed better on learning performance.

However, the modality principle and segmenting principle have not been empirically compared each other. Both principles tend to reduce cognitive overload, but, the modality principle may not be found with a segmented instructional animation, because segmentation already reduce the amount of information. Next, little research has investigated other stimuli during pauses between segments. Even though the previous studies revealed the effect of the pause, the pause could be considered a passive way for learning. In other words, learners are responsible to encode the information during the pause. In contrast, we employed cued recall questions that require learners to not only encoding information but also retrieving information to answer questions.
Method

Participants
We collected data from ninety six undergraduate students at a large southwestern university (Female: 59, Male: 37; Freshman: 27, Sophomore: 37, Junior: 28, Senior: 4).

Instructional animation
The instructional animation was about the formation of lightning. Based on the original instruction that contains 16 static slides with text (Mayer & Chandler, 2001), we created four 40-second animations that cover each four steps. All segmented animation contained either spoken text (i.e., narration) or written text (i.e., on-screen text).

Data collection
There were four groups depending on segmentation condition (cued recall vs. pause only) and modality condition (written text vs. spoken text). Regarding segmentation condition, group 1 and 2 were asked to take two embedded short-answer questions (i.e., cued recall) from the previous segment at the end of each four segmented animation, while group 3 and 4 had a pause between segments. The groups with pause (3 and 4) were asked to answer the eight embedded questions at the end of all four segments in order to determine the difference of the scores in terms of cued recall occasion. There was no limited time for either cured recall or pause only between segments. Regarding modality condition, a narration as spoken text was provided to group 1 and 3, and written text was presented inside of the animation in group 2 and 4.

The participants were randomly assigned to one group and were asked to complete questionnaire about demographic information and prior knowledge. Next, they took the instruction about the formation of lightning. Last, they were asked to take a retention test and four transfer tests. All tests including the embedded questions were open-ended and scored by authors with cross check. For the retention test, two more data were calculated: (a) scores for items related to the cued recall questions, and (b) scores for items unrelated to the cued recall questions.

Results
Table 1 shows the means and standard deviations for each of the learning outcome. Separate 2 (modality: written text vs. spoken text) X 2 (segmenting: cued recall vs. pause only) between-subjects ANOVAs were conducted on all measures.

Table 1. Means and Standard Deviations for All Measures

<table>
<thead>
<tr>
<th></th>
<th>Segmenting with Cued Recall</th>
<th>Segmenting with Pause Only</th>
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<tbody>
<tr>
<td></td>
<td>Written Text (n = 25)</td>
<td>Spoken Text (n = 25 )</td>
</tr>
<tr>
<td>Cued Recall Questions</td>
<td>7.08 (3.01)</td>
<td>8.04 (2.26)</td>
</tr>
<tr>
<td>Retention Test</td>
<td>5.12 (3.30)</td>
<td>6.24 (3.99)</td>
</tr>
<tr>
<td></td>
<td>2.76 (2.20)</td>
<td>3.64 (2.22)</td>
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<tr>
<td></td>
<td>2.36 (1.44)</td>
<td>2.60 (1.96)</td>
</tr>
<tr>
<td>Transfer Test</td>
<td>4.76 (2.50)</td>
<td>5.16 (1.91)</td>
</tr>
</tbody>
</table>

* Standard deviations are presented in parenthesis

We found that the segmentation effect was significant while no significant results were found for the modality effect and interaction effect. In regard to the segmentation condition, groups with cued recall outperformed group with pause only on cued recall questions (F(1, 92) = 21.768, MSE = 134.293, p < .001), retention test (F(1, 92) = 9.140, MSE = 85.861, p = .003), and transfer test (F(1, 92) = 18.862, MSE = 95.899, p < .001). The difference of the retention test was caused by the significant difference in the scores related to the cued recall questions (F(1,
92) = 14.215, MSE = 45.827, p < .001) rather than unrelated scores that was not significant (F(1, 92) = 2.461, MSE = 6.233, p = .120). On the other hand, the modality effect was not significant on all measures: embedded questions (F(1, 92) = 1.307, MSE = 8.062, p = .256), retention test (F(1, 92) = 2.459, MSE = 23.097, p = .120), and transfer test (F(1, 92) = .188, MSE = .600, p = .732).

Discussion and Conclusions

The results showed the superior test performance of segmentation with cued recall regardless of the modality condition. Cued recall task was more effective than pause only between segments. Pauses might provide learners with sufficient time to process transient information without having to simultaneously attend to the next unit of information (e.g., Mayer & Moreno 2003: Moreno & Mayer 2007). However, we conjecture that embedded cued recall may promote germane cognitive load by requiring learners to respond to a set of questions directly from the animation (Ayres & Paas, 2007). The findings imply that a stimulus (i.e., cued recall) between segments could enhance cognitive processing in instructional animation.

This study has a number of limitations. First, the higher learning performance may not be simply due to the embedded recall between segments, because the average time spent for whole instruction in the cued recall groups was 104 seconds longer than the average time spent in the pause groups. We did not measure time the participants spent between segments. A further study should investigate whether the effect of cued recall was due to more time or recall test itself. Thus, system controlled length of time for both pause and cued recall between segments may answer the question. Second, different types of stimuli between segments could be investigated. For example, a simple message for learners to reflect information presented or a short summary text could be considered for further studies. Last, appropriate lengths of segment should be investigated with learners’ prior knowledge. This study predefined the length of the segments, but a further study may explore the differences of the length of segments depending on learners’ characteristics.

References


