What Students Learn from Instructional Video: Applications of the Cognitive Theory of Multimedia Learning
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Background & Hypotheses
Mayer’s Cognitive Theory of Multimedia Learning (CTML) argues that our ability to learn from multimedia instruction is constrained by our limited processing capacity in visual and auditory channels. This implies that multimedia instruction will be more successful to the extent that it manages the demands on our cognitive processing capacity.

Consistent with this idea, Mayer has investigated several principles of multimedia instruction that minimize extraneous processing and manage essential processing in a multimedia lesson. One of those is called the segmenting principle, which suggests that students learn more when key information is highlighted. Another is the segmenting principle, which shows that students learn more when they have some control over the pace of a lesson. Both of these principles have been supported in multiple experiments, with effect sizes ranging from 0.5 to 1.0, but generally using relatively simple lessons and materials.

The goal of these studies was to demonstrate the applicability of the signaling and segmenting principles using popular instructional videos found on YouTube. We manipulated these videos by breaking the lesson into short segments and providing informative headings for each segment. We predicted that students would learn more from a segmented lesson than a continuous one, and that the degree of learning (measured via both retention and transfer) would be greater when the headings more directly highlighted key information.

Design & Procedure
Study 1: 4 levels, between-subjects
82 Mturkers (46 female; M_w = 36.4 years)
Study 2: 4 levels, within-subjects
80 Mturkers (53 female; M_w = 37.2 years)
Study 3: 2 levels, within-subjects
51 Mturkers (34 female; M_w = 39.4 years)
Study 4: 4 levels, between-subjects
95 UCLA undergrads (60 female; M_w = 20.1 years)
Study 5: 4 levels, between-subjects, 24-hour retention interval
102 UCLA undergrads (73 female; M_w = 20.7 years)

Between-subjects design:
Video with NO HEADINGS
Video with pausing but NO HEADINGS
Retention/Transfer
Prior Knowledge Vocabulary Rating

Within-subjects design:
Segment 1 | Segment 2 | Segment 3 | Segment 4 | Segment 5 | Segment 6 | Segment 7 | Segment 8
--- | --- | --- | --- | --- | --- | --- | ---
Video 1 | Pause | Number | Title | Question | Title | Question | Number | Pause
Video 2 | Number | Title | Question | Pause | Title | Question | Pause | Number
Video 3 | Title | Question | Pause | Number | Title | Question | Pause | Number
Video 4 | Question | Pause | Number | Title | Question | Pause | Number | Title

Materials
Crash Course lesson on Kidney Function:

Segments & Headings:

<table>
<thead>
<tr>
<th>Segments</th>
<th>Length</th>
<th>Title Heading</th>
<th>Quantity Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68 sec</td>
<td>Homework &amp; Dose</td>
<td>How does the kidney help maintain homeostasis and aid in homeostasis?</td>
</tr>
<tr>
<td>2</td>
<td>102 sec</td>
<td>Urine &amp; Acidosis</td>
<td>What is the difference between urine and acidosis?</td>
</tr>
<tr>
<td>3</td>
<td>70 sec</td>
<td>Kidneys &amp; Neptunas</td>
<td>What does the Eiffel Tower have to do with the kidneys?</td>
</tr>
<tr>
<td>4</td>
<td>44 sec</td>
<td>Glomerulus &amp; Bowman’s Capsule</td>
<td>What is the main function of the glomerulus and Bowman’s capsule?</td>
</tr>
<tr>
<td>5</td>
<td>45 sec</td>
<td>Proximal Convoluted Tubule</td>
<td>What substances are reabsorbed in the proximal convoluted tubule?</td>
</tr>
<tr>
<td>6</td>
<td>35 sec</td>
<td>Renal Cortex &amp; Medulla</td>
<td>What is the difference between the renal cortex and renal medulla?</td>
</tr>
<tr>
<td>7</td>
<td>45 sec</td>
<td>Loop of Henle</td>
<td>What does the loop of Henle do?</td>
</tr>
<tr>
<td>8</td>
<td>30 sec</td>
<td>Descending limbs</td>
<td>What substances are reabsorbed in the descending limb?</td>
</tr>
<tr>
<td>9</td>
<td>32 sec</td>
<td>Ascending limb</td>
<td>What substances are absorbed in the ascending limb?</td>
</tr>
<tr>
<td>10</td>
<td>26 sec</td>
<td>Distal Convoluted Tubule</td>
<td>What substances are reabsorbed in the distal convoluted tubule?</td>
</tr>
<tr>
<td>11</td>
<td>58 sec</td>
<td>Collecting duct</td>
<td>What function does the collecting duct?</td>
</tr>
<tr>
<td>12</td>
<td>57 sec</td>
<td>Ureters, Bladder, &amp; urethra</td>
<td>How do the ureters, bladder, and urethra work together to execute urine?</td>
</tr>
</tbody>
</table>

Prior Knowledge Vocabulary Rating:

Which of the following terms do you feel confident you could define? (before video)

Prior Knowledge Self-Rating:
How much did you know about this topic before watching the video? (after video)

Results

Retention posttest
1 Open response – summarize the lesson
12 Multiple Choice – answers were given directly in the lesson

Transfer posttest
1 Open response – reason about a novel situation
12 Multiple Choice – answers could be inferred from the lesson

Attention check:
What did you do during the pauses?

Discussion
We failed to find a significant effect of either signaling or segmenting across 5 studies, using a variety of subject pools and within- and between-subject designs.

The strongest effect in all of the studies was the influence of prior knowledge, which consistently predicted retention, but not always transfer. In some experiments, only participants with high prior knowledge benefited from question headings (study 3) – and only on the retention test – but in most of the experiments there was no significant interaction between prior knowledge and segment heading.

When collapsing across conditions to compare segmented versus continuous lessons and controlling for prior knowledge score, there was no significant effect of signaling on either retention or transfer. Similarly, when collapsing across conditions to compare lessons with headings versus lessons without headings (and controlling for prior knowledge), there was no significant effect of headings for either retention or transfer.

When asked what they did during pauses in the lesson, the vast majority of participants indicated that they pressed “play” right away. The way participants treated the pauses was a potential explanation for the lack of an effect, but samples sizes were too small to be reliable.

Future Directions
Exploring key differences between materials commonly used in Mayer’s work and the kinds of instructional videos that are prevalent online (e.g., length, speed, complexity, etc.)

Identifying possible boundary conditions for the effectiveness of Mayer’s principles of multimedia instruction
Specifically exploring the relationship between segment length and benefits of segmenting a lesson
Investigating different effects of prior knowledge by experimentally manipulating pre-training on key vocabulary, as well as comparing different subject populations (e.g., completely naïve versus experienced biology students)

References