CHAPTER OUTLINE

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Coherence Principle 2: Avoid e-Lessons with Extraneous Graphics
Psychological Reasons to Avoid Extraneous Graphics in e-Learning
Evidence for Omitting Extraneous Graphics Added for Interest
Evidence for Using Simpler Visuals

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Evidence for Omitting Extraneous Words Added for Technical Depth
Perhaps our single most important recommendation is to keep the lesson uncluttered. In short, according to the coherence principle, you should avoid adding any material that does not support the instructional goal. The *coherence principle* is important because it is commonly violated, is straightforward to apply, and can have a strong impact on learning. Mayer and Moreno (2003) use the term *weeding* to refer to the need to uproot any words, graphics, or sounds that are not central to the instructional goal of the lesson. In spite of our calls for conciseness, you might be tempted to embellish lessons in an effort to motivate learners. For example, in order to counter high e-learning dropout rates, some designers attempt to spice up their materials by adding entertaining or motivational elements such as dramatic stories, pictures, or background music. Our advice is: *Don't do it!* In this chapter we summarize the empirical evidence for excluding rather than including extraneous information in the form of background
sound, added text, and added graphics. What is new in this chapter is some updating of the growing research base, but the main conclusion remains the same: Adding interesting but unnecessary material to e-learning can harm the learning process.

**DESIGN DILEMMA: YOU DECIDE**

“This spreadsheet lesson is pretty boring. We are dealing with the YouTube and videogame generation here. They are used to high-intensity multimedia. But don’t worry! I’ve added some really important information that everyone should know about spreadsheets and I’ve energized the information with some visual effects. Take a look at this example. On this screen (Figure 8.1), I’m giving them some key historical information about the evolution of electronic spreadsheets.”

Ben, the team programmer, has challenged the idea of a simple e-learning program—especially for younger learners. Reshmi, the instructional designer agrees:

**Figure 8.1. A Screen to Add Interest to the Excel Lesson.**

Dan Bricklin, one of the inventors of the electronic spreadsheet watched his university professor create a table of calculation results on a blackboard. When the professor found an error, he had to tediously erase and rewrite a number of sequential entries in the table.

This gave Bricklin the idea to replicate the process on a computer, using the blackboard as the model to view results of underlying formulas. This idea resulted in VisiCalc, the first electronic spreadsheet which became the ‘killer app’ for the Apple II computer!
“Ben is right. We know that dropout rates from asynchronous e-learning are high. By adding some interesting information about spreadsheets throughout the lesson, we can hold everyone’s interest. In fact, I learned in an accelerated learning class that soft background classical music helps people retain information better. Could we add a soft instrumental to the narration?”

Matt, the project manager, interjects: “How much will the extra visual and audio effects add to the budget and delay our timeline?” Shouldn’t we just stick to the basics?” Based on your intuition or experience, which of the following options do you choose:

A. Ben is correct. Adding some interesting words and visuals will improve interest and learning—especially among younger learners.

B. Reshmi is correct. Learning is better in the presence of soft music—especially classical music.

C. Matt is right. Less is more for most learners.

D. Everyone is correct. Different learners benefit from different instructional methods.

The added sounds, graphics, and words such as those in Figure 8.1 are examples of seductive details, interesting but irrelevant material added to a multimedia presentation in an effort to spice it up (Garner, Gillingham, & White, 1989). The following three sections explore the merits of adding extra sounds, pictures, and words that are intended to make multimedia environments more interesting to the learner.

**Coherence Principle 1: Avoid e-Lessons with Extraneous Audio**

First, consider the addition of background music and sounds to a narrated animation. Is there any theoretical rationale for adding or not adding music and sounds, and is there any research evidence? These questions are addressed in this section.
Based on the psychology of learning and the research evidence summarized in the following paragraphs, we recommend that you avoid e-learning courseware that includes extraneous sounds in the form of background music or environmental sounds. Like all recommendations in this book, this one is limited. Recommendations should be applied based on an understanding of how people learn from words and pictures rather than a blind application of rules in all situations.

Background music and sounds may overload working memory, so they are most dangerous in situations in which the learner may experience heavy cognitive load, for example, when the material is unfamiliar, when the material is presented at a rapid rate, or when the rate of presentation is not under learner control. More research is needed to determine whether there are some situations in which the advantages of extraneous sounds outweigh the disadvantages. For example, in a review of twelve award-winning instructional

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**Figure 8.2. Sounds of Explosion and Bullets Added to Narration of On-Screen Text.**

<table>
<thead>
<tr>
<th>INTRODUCTION TO AMMUNITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>This energy is used to do several possible things.</td>
</tr>
<tr>
<td>* PROPEL SOMETHING SUCH AS A BULLET, OR AN ARTILLERY PROJECTILE.</td>
</tr>
<tr>
<td>* BURST OPEN AN AMMUNITION ITEM CONTAINING A CHEMICAL FILLER.</td>
</tr>
</tbody>
</table>

**Audio:** Explosions and narration of onscreen text
software products, Bishop, Amankwaita, and Cates (2008) found that sound was sometimes used to direct, focus, and hold the learner’s attention and music was used to promote deeper processing—but there was no evidence of their effectiveness. Additionally, sound effects have been used to provide feedback in educational games (Mayer & Johnson, 2010)—but again there is not convincing evidence of their effectiveness. At this point, our recommendation is to avoid adding extraneous sounds or music to instructional presentations, especially in situations in which the learner is likely to experience heavy cognitive processing demands.

For example, Figure 8.2 shows a screen from a military multimedia lesson on ammunition. As the lesson illustrates the different types of ammunition that workers may encounter, background sounds such as bullets flying, bombs exploding, and tanks firing are included. These sounds are extraneous to the points being presented and are likely to prove distracting. Figure 8.3 shows

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**Figure 8.3. Learners Can Select Music During Course Introduction.**

![INTRODUCTION TO AMMUNITION](image)
a screen from the same program that invites the learners to select the type of background music they want to hear during the course introduction. Again, the addition of extra sounds in the form of music is likely to depress learning.

**Psychological Reasons to Avoid Extraneous Audio in e-Learning**

For some learners e-learning can seem boring, and you might be concerned with reports that claim high dropout rates in e-learning (Svetcov, 2000). Therefore, developers may feel compelled to spice up their materials to arouse the learner’s interest. Similarly, consumers may feel that a “jazzier” product is especially important for the new generation of learners raised on high intensity multimedia such as YouTube and videogames. This is the premise underlying arousal theory, the idea that entertaining and interesting embedded effects cause learners to become more emotionally aroused and therefore they work harder to learn the material. In short, the premise is that emotion (for example, arousal caused by emotion-grabbing elements) affects cognition (for example, higher cognitive engagement). Arousal theory predicts that students will learn more from multimedia presentations that contain interesting sounds and music than from multimedia presentations without interesting sounds and music.

Arousal theory seems to make sense, so is there anything wrong with it? As early as 1913, Dewey argued that adding interesting adjuncts to an otherwise boring lesson will not promote deep learning: “When things have to be made interesting, it is because interest itself is wanting. Moreover, the phrase is a misnomer. The thing, the object, is no more interesting than it was before” (pp. 11–12). The theoretical rationale against adding music and sounds to multimedia presentations is based on the cognitive theory of multimedia learning, which assumes that working memory capacity is highly limited. Background sounds can overload and disrupt the cognitive system, so the narration and the extraneous sounds must compete for limited cognitive resources in the auditory channel. When learners pay attention to sounds and music, they are less able to pay attention to the narration describing the relevant steps in the explanation. The cognitive theory of multimedia learning
predicts that students will learn more deeply from multimedia presentations that do not contain interesting but extraneous sounds and music than from multimedia presentations that do.

Evidence for Omitting Extraneous Audio

Can we point to any research that examines extraneous sounds in a multimedia presentation? Moreno and Mayer (2000a) began with a three-minute narrated animation explaining the process of lightning formation and a forty-five-second narrated animation explaining how hydraulic braking systems work. They created a music version of each by adding a musical loop to the background. The music was an unobtrusive instrumental piece, played at low volume that did not mask the narration nor make it less perceptually discernable. Students who received the narrated animation remembered more of the presented material and scored higher on solving transfer problems than students who received the same narrated animation along with background music. The differences were substantial—ranging from 20 to 67 percent better scores without music—and consistent for both the lightning and brakes presentations. Clearly, adding background music did not improve learning, and in fact, substantially hurt learning.

Moreno and Mayer (2000a) also created a background sound version of the lightning and brakes presentations by adding environmental sounds. In the lightning presentation, the environmental sounds included the sound of a gentle wind (presented when the animation depicted air moving from the ocean to the land), a clinking sound (when the animation depicted the top portion of cloud forming ice crystals), and a crackling sound (when the animation depicted charges traveling between ground and cloud). In the brakes presentation, the environmental sounds included mechanical noises (when the animation depicted the piston moving forward in the master cylinder) and grinding sounds (when the animation depicted the brake shoe pressing against the brake drum). On the lightning presentation, students who received the narrated animation without environmental sounds performed as well on retention and transfer as students who received the narrated animation with environmental sounds; on the brakes presentation, students who
received narrated animation performed better on retention and transfer than students who received the narrated animation with environmental sounds.

For both lightning and brakes presentations, when students received both background music and environmental sounds, their retention and transfer performance was much worse than when students received neither—ranging between 61 to 149 percent better performance without the extraneous sounds and music. The average percentage gain from all the studies was 105 percent, with a very high effect size of 1.66. Figure 8.4 shows a result from one of these studies.

![Figure 8.4. Learning Is Better When Sounds and Music Are Excluded.](image)

Related evidence points to the mental toll that can be levied by extraneous sounds. Knez and Hygge (2002) compared learning from a seven-page text read in a quiet environment with learning from reading the same text in the presence of irrelevant conversational background speech. Recall of text ideas was significantly better among those reading in a silent environment. Ransdell and Gilroy (2001) compared the quality and efficiency of essay writing in the presence of music (vocal and instrumental) with writing in a quiet environment. They found that the quality of the essays was similar
in all conditions but that those working in the presence of music required significantly more time. To maintain quality, writers slow down their production in the presence of background music. The research team recommends that: “For all those college students who listen to music while they write on a computer, the advice from this study is clear. One’s writing fluency is likely to be disrupted by both vocal and instrumental music” (p. 147).

Coherence Principle 2: Avoid e-Lessons with Extraneous Graphics

The previous section shows that learning is depressed when we add extraneous sounds to a multimedia presentation, so perhaps we should try another way to spice up our lessons, namely interspersing interesting video clips. For example, in a database lesson we could insert some news video discussing recent database thefts from government agency computers. What is the learning impact of adding related but not directly relevant pictures and video clips to e-learning lessons?

Based on what we know about human learning and the evidence we summarize next, we offer a second version of the coherence principle: Avoid adding extraneous pictures. This recommendation does not mean that interesting graphics are harmful in all situations. Rather, they are harmful to the extent that they can interfere with the learner’s attempts to make sense of the presented material. Extraneous graphics can be distracting and disruptive of the learning process. In reviews of science and mathematics books, most illustrations were found to be irrelevant to the main theme of the accompanying lesson (Mayer, 1993; Mayer, Sims, & Tajika, 1995). In short, when pictures are used only to decorate the page or screen, they are not likely to improve learning. As an example, Figure 8.5 shows a screen from our sample pharmaceutical sales lesson that includes graphics and words about obesity—content related to the topic but distracting and irrelevant to the learning objective. Some of the information is quite interesting but not related to the knowledge and skills needed to effectively explain the product. We recommend excluding this type of information.
Psychological Reasons to Avoid Extraneous Graphics in e-Learning

Pictures—including color photos and action video clips—can make a multimedia experience more interesting. This assertion flows from arousal theory—the idea that students learn better when they are emotionally aroused. In this case, photos or video segments are intended to evoke emotional responses in learners, which in turn are intended to increase their level of cognitive engagement in the learning task. Thus, pictures and video are emotion-grabbing devices that make the learner more emotionally aroused, and therefore more...
actively involved in learning the presented material. Arousal theory predicts that adding interesting but extraneous pictures will promote better learning.

What’s wrong with this justification? The problem—outlined in the previous section—is that interest cannot be added to an otherwise boring lesson like some kind of seasoning (Dewey, 1913). According to the cognitive theory of multimedia learning, the learner is actively seeking to make sense of the presented material. If the learner is successful in building a coherent mental representation of the presented material, the learner experiences enjoyment. However, adding extraneous pictures can interfere with the process of sense-making because learners have a limited cognitive capacity for processing incoming material. According to Harp and Mayer (1998), extraneous pictures (and their text captions) can interfere with learning in three ways:

- **Distraction**—by guiding the learner’s limited attention away from the relevant material and toward the irrelevant material,
- **Disruption**—by preventing the learner from building appropriate links among pieces of relevant material because pieces of irrelevant material are in the way, and
- **Seduction**—by priming inappropriate existing knowledge (suggested by the added pictures), which is then used to organize the incoming content.

Thus, adding interesting but unnecessary material—including sounds, pictures, or words—to e-learning can harm the learning process by preventing the learner from processing the essential material. The cognitive theory of multimedia learning, therefore, predicts that students will learn more deeply from multimedia presentations that do not contain interesting but extraneous photos, illustrations, or video.

**Evidence for Omitting Extraneous Graphics Added for Interest**

What happens when entertaining but irrelevant video clips are placed within a narrated animation? Mayer, Heiser, and Lonn (2001) asked students to view a three-minute narrated animation on lightning formation, like the one
described in the previous section. For some students, the narrated animation contained six ten-second video clips intended to make the presentation more entertaining, yielding a total presentation lasting four minutes. For example, one video clip showed trees bending against strong winds, lightning striking into the trees, an ambulance arriving along a path near the trees, and a victim being carried in a stretcher to the ambulance near a crowd of onlookers. At the same time, the narrator said: “Statistics show that more people are injured by lightning each year than by tornadoes and hurricanes combined.”

This video clip and corresponding narration were inserted right after the narrated animation describing a stepped leader of negative charges moving toward the ground. Thus, the narrated video was related to the general topic of lightning strikes but was not intended to help explain the cause-and-effect chain in lightning formation.

Students who received the lightning presentation without the inserted video clips performed better on solving transfer problems than students who received the lightning presentation with inserted video clips—producing about 30 percent more solutions, which translated into an effect size of .86. Mayer, Heiser, and Lonn (2001, p. 187) note that this result is an example of “when presenting more material results in less understanding.”

Harp and Mayer (1997) found a similar pattern of results using a paper-based medium. Some students were asked to read a 550-word, six-paragraph passage containing six captioned illustrations. The passage described the cause-and-effect sequence leading to lightning formation, and the captioned illustrations depicted the main steps (with captions that repeated the key events from the passage). Each illustration was placed to the left of the paragraph it depicted. Other students read the same illustrated passage, along with six color pictures intended to spice up the presentation. Each picture was captioned and was placed to the right of a paragraph to which it was related. For example, next to the paragraph about warm moist air rising, there was a color photo of an airplane being hit by lightning accompanied by the following text: “Metal airplanes conduct lightning very well, but they sustain little damage because the bolt, meeting no resistance, passes right through.” In another section of the lesson, a photo of a burned uniform from a football player stuck by lightning was included. Figure 8.6 shows an example of one of these visuals.
Students who received the lightning passage without added color photos performed better on retention and transfer tests than students who received the lightning passage with color photos, generating about 52 percent more solutions on the transfer test, which translates into an effect size greater than 1. This is another example of how adding interesting but irrelevant graphics can result in less learning from a multimedia presentation. In each of four follow-up experiments, Harp and Mayer (1998) found that adding interesting but irrelevant captioned illustrations to the lightning lesson tended to hurt student performance on subsequent transfer tests, yielding effect sizes greater than 1.

For those who argue that these guidelines won’t apply to the new generation raised on high-intensity media, we should mention that all of the above research was conducted with young adults. The subjects in these experiments were college-aged students ranging in age from eighteen to twenty-two years. Therefore, we cannot agree that members of the younger generation are less susceptible to mental overload as a result of intensive multimedia exposure.
Sanchez and Wiley (2006) identified a possible boundary condition for the coherence principle: Adding irrelevant illustrations to scientific text hurt learning particularly for students who have lower capacity for processing information. (For example, if we read a short list of words to these low-ability learners, they would make mistakes reciting the words back to us.) Apparently, the low-ability students were more easily overloaded by the extraneous material. In a follow-up study involving eye-tracking, low-ability students spent more time looking at irrelevant illustrations than did high-working-memory students, indicating that extraneous graphics can be particularly distracting for learners with low ability. Overall, it appears that good design principles—such as the coherence principle—are particularly important for the most at-risk learners.

Evidence for Using Simpler Visuals

In the previous section we focused on visuals that were extraneous to the learning goal. As we saw, adding extraneous visuals depressed learning. In this section, we recommend using simpler visuals, especially when understanding of a process or principles is the goal. By “simple” we mean visuals with fewer details presented at one time. For example, among static graphics, a two-dimensional line drawing is simpler than a three-dimensional drawing or a photograph. A series of static line drawings that can be viewed one at a time is simpler than an animation that presents a great deal of visual information in a transitory manner. Among animations, a computer-generated visual that omits extraneous elements in the background is simpler than a video that records all visual elements in the scene.

We have several research studies in which a simpler graphic led to better learning than a more realistic or complex visual. For example, Butcher (2006) asked college students to study a lesson on the human heart that contained text and simple illustrations or text and detailed illustrations, as shown in Figure 8.7. On subsequent tests of understanding of how the heart works, the students who had learned with text and simple drawings performed better than those who had learned with text and detailed drawings.
During learning, students who studied text and simple illustrations made more integration inferences—indicating an attempt to understand how the heart works—than did students who studied text and complex illustrations. Compare the visuals in Figure 8.8. Scheiter, Gerjets, Huk, Imhof, and Kammerer (2009) found that schematic animations were more effective than video recorded animations in a multimedia lesson on cell replication.
Multiple-choice tests and visual identification tests were used to measure learning. The simpler schematic animation led to better scores on the multiple-choice test and supported accurate visual identification of realistic images, even though the learners in the schematic group never saw realistic images. The research team concludes: “It seems that learners [in the video group] were overwhelmed with the amount of realistic detail and failed to come to a proper understanding of the process of mitosis” (p. 9).

In Chapter 4, we reviewed research reported by Mayer, Hegarty, Mayer, and Campbell (2005) that compared a series of static visuals with an animation of processes such as how a toilet flushes and how brakes work. The static visuals led to learning that was better than or equal to the animated versions.

Taken together this research sounds a cautionary note to those considering highly realistic learning or simulation interfaces. Of course, there are likely some learning goals that may benefit from more realistic visuals, and we look forward to additional research for clarification on this issue.

Coherence Principle 3: Avoid e-Lessons with Extraneous Words

Our third version of the coherence principle recommends that you should avoid adding extraneous words to lessons. When the goal is to promote learning of the target material—such as the workings of a cause-and-effect system—adding interesting but extraneous words may result in poorer learning.

This guideline is helpful when limited screen real estate and bandwidth suggest shorter rather than longer narrations. Rather than fully embellished textual or narrative descriptions, as in Figure 8.9, stick to basic and concise descriptions of the content, as in Figure 8.10. It also helps implement the modality principle effectively. By keeping the narration on each screen concise, learners won’t become as frustrated waiting for lengthy audio segments to play.
Figure 8.9. Extensive Text Overly Details Spreadsheet Concepts.

Absolute VS Relative Cell References

When you copy a formula containing cell references into a new cell, all of the cell references will update to reflect the new location. For example, if you copy the formula =B1+B3 from cell B4 to cell C4, the formula will automatically update to: =C1+C3. This is called relative cell references.

However, sometimes you may want the value in one or more of the cells in your source formula to remain constant. For example if you applied a commission of 10% given to all sales staff in January to February sales, you would not want the 10% value to change. Holding a cell value constant when it is copied is called an absolute cell reference and is designated by placing a dollar sign in front of the column and row number you want to copy unchanged. For example: =B4*$B$10.

Figure 8.10. Lean Text and Relevant Visual Explain Spreadsheet Concepts.

Cell B9 is designated as an absolute cell reference.

When you want to keep a cell value in a copied formula the same, you need to use an absolute cell reference. Place a dollar sign in front of the column letter and row number of the cell value you want to maintain.

Note above in column C the value in each B column will be multiplied by 10% when the formula in Cell C4 is copied to C5 – C7.
Psychological Reasons to Avoid Extraneous Words in e-Learning

For the same reasons that extraneous sounds and graphics can be distracting, adding extra words can interfere with the learning process. We address three types of extraneous wording. First, additional words may be added for interest. The extra words are related to the topic but are not relevant to the primary instructional goal. Second, extra words may be added to expand upon the key ideas of the lesson. A third purpose for extra words is to add technical details that go beyond the key ideas of the lesson. Subject-matter experts like to incorporate considerable amounts of technical information that expands on the basics. We recommend against extraneous words added for interest, for elaboration, or for technical depth.

Evidence for Omitting Extraneous Words Added for Interest

Do students learn more deeply from a narrated animation when interesting verbal information is added to the narration? To address this question, Mayer, Heiser, and Lonn (2001) asked some students to view a three-minute narrated animation about lightning formation, like the one described in the previous section. Other students viewed the same three-minute presentation, but with six additional narration segments inserted at various points. The narration segments were short and fit within the three-minute presentation at points that otherwise were silent. For example, after saying that water vapor forms a cloud, the narrator added: “On a warm, cloudy day, swimmers are sitting ducks for lightning.” Similarly, after saying that electrical charges build in a cloud, the narrator added: “Golfers are vulnerable targets because they hold metal clubs, which are excellent conductors of electrical charges.” Students who received the lightning presentation without additional narration segments performed better on transfer tests than students who received the lightning presentation with added narration segments—generating about
34 percent more solutions on the transfer test, which translated into an effect size of .66.

In a related study, Lehman, Schraw, McCrudden, and Hartley (2007) found that college students who read the lightning lesson with seductive details spent less time reading the relevant text, recalled less of the relevant text, and showed shallower processing on an essay task as compared to students who read the lightning passage without seductive details. These results show that adding seductive details harms learning by distracting learners from the important information and by disrupting the coherence of the lesson.

Finally, consider what happened when college students received a PowerPoint multimedia lesson explaining how a virus causes a cold or how the human digestive system works. The lesson consisted of series of slides with text and an illustration on each one, but some students also received interesting sentences mainly about sex or death embedded in the text. We show the two versions in Figure 8.11. Won’t the interesting material help students pay

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Figure 8.11. High and Low Interest Statements Added to a Lesson.

**A. High Interest Statement:**
A study conducted by researchers at Wilkes University in Wilkes-Barre, Pennsylvania, reveals that people who make love once or twice a week are more immune to colds than folks who abstain from sex. Researchers believe that bedroom activity somehow stimulates an immune-boosting antibody called IgA.

**B. Low-Interest Statement:**
A virus is about 10 times smaller than a bacterium, which is approximately 10 times smaller than a typical human cell. A typical human cell is 10 times smaller than a human hair. Therefore, it can be concluded that a virus is about 1000 times smaller than a human hair.
better attention and therefore learn better? As you can see in Figure 8.12, the answer is clearly “no.” Mayer, Griffith, Jurkowitz, and Rothman (2008) found that college students actually learned less from lessons containing highly interesting seductive details than from lessons containing less interesting seductive details. It appears that increasing the interestingness of the seductive details created greater distraction away from the important material in the lessons.

Again, these results show that adding interesting but irrelevant material does not help learning, and in this case even hurts learning.

**Evidence for Omitting Extraneous Words**

**Added to Expand on Key Ideas**

In a more extreme version of this research (Mayer, Bove, Bryman, Mars, & Tapangco, 1996), students read the standard lightning passage like the one described above (that is, with six hundred words and five captioned illustrations) or a summary consisting of five captioned illustrations. The captions described the main steps in the lightning formation and the corresponding illustrations depicted the main steps. Approximately eighty words—taken
from the standard passage—were used in the captioned illustrations. In three separate experiments, students who read the summary performed better on tests of retention and transfer than students who received the whole passage—in some cases, producing twice as many steps in the causal chain on the retention test and twice as many solutions on the transfer test. Figure 8.13 shows results from one of the experiments in this study. Mayer, Bove, Bryman, Mars, and Tapangco (1996, p. 64) conclude that this research helps show “when less is more.”

Figure 8.13. Learning Is Better When Non-Essential Text Is Excluded.
Adapted from Mayer, 2001a.

More recently, Mayer, Deleeuw, and Ayres (2007) extended the coherence principle by examining what happens when you add material to a multimedia lesson on how hydraulic brakes work. The added material consisted of companion multimedia lessons on how caliper brakes work and on how air brakes work. College students performed better on retention and transfer tests concerning hydraulic brakes if they received a multimedia lesson only about hydraulic brakes rather than the same hydraulic brake lesson along with lessons on two other kinds of braking systems.

Overall, providing a concise summary of what you want students to learn results in better learning than providing the same material along with additional complementary material.
Evidence for Omitting Extraneous Words Added for Technical Depth

Mayer and Jackson (2005) compared learning from a multimedia lesson on how ocean waves work in concise form with one that included additional technical information. The embellished version contained additional words and graphics about computational details, such as how to apply formulas related to ocean waves. The versions with additional quantitative details depressed performance on a subsequent problem-solving transfer test focusing on conceptual understanding—yielding effect sizes of .69 for a computer-based lesson and .97 for a paper-based lesson. Mayer and Jackson (2005, p. 13) conclude that “the added quantitative details may have distracted the learner from constructing a qualitative model of the process of ocean waves.” In an important follow-up study, Verkoeijen and Tabbers (2009) replicated this finding with Dutch students.

In short, when tempted to add more words, ask yourself whether additional verbiage is really needed to achieve the instructional objectives. If not, weed out extra words!

What We Don’t Know About Coherence

As you can see in this chapter, there is strong and consistent support for the coherence effect. In the latest review, Mayer (2008) listed positive results for eliminating extraneous materials in thirteen out of fourteen experiments, with a median effect size near 1. In spite of this initial body of useful research evidence, there is still much we do not know about the coherence principle. Much of the research reported in this chapter deals with short lessons delivered in a controlled lab environment. Does the coherence effect also apply to longer term instruction presented in an authentic learning environment, such as a training program? It would be useful to determine whether students can learn to ignore irrelevant material or whether lessons can be redesigned to highlight relevant material—a technique that can be called signaling (Mautone & Mayer, 2001; Mayer,
Chapter 8: Applying the Coherence Principle

2005b; Mayer & Moreno, 2003). Signaling includes using headings, bold, italics, underlining, capital letters, larger font, color, white space, arrows, and related techniques to draw the learner's attention to specific parts of the display or page. Preliminary research (de Koning, Tabbers, Rikers, & Paas, 2010; Harp & Mayer, 1997; Mautone & Mayer, 2001) shows that signaling can improve learning from multimedia lessons, but additional research is needed.

When it comes to educational games and simulations, sound effects and music may play a useful role under some circumstances, but currently there is insufficient evidence to guide instructional game designers.

In addition, we do not know much about how individual characteristics of learners are related to the effectiveness of the coherence principle. Most of the research reported in this chapter is based on learners who are novices—that is, who lack prior knowledge in the domain of the lesson. Does the coherence effect also apply to high-knowledge learners? Research on the expertise reversal effect (Kalyuga, 2005) suggests that instructional design techniques that are effective for beginners may not be effective for more experienced learners. For example, Mayer and Jackson (2005) found that adding computational details hurt learning for beginners, but it is possible that students who had extensive physics backgrounds might have benefited from the added material. Similarly, research by Sanchez and Wiley (2006) provides preliminary evidence that adding irrelevant material can be particularly damaging for lower-ability learners. In short, research is needed to determine for whom the coherence principle applies.

Finally, you should not interpret the coherence principle to mean that lessons should be boring. There is ample evidence that students learn better when they are interested in the material (Hidi & Renninger, 2006). However, the challenge for instructional professionals is to stimulate interest without adding extraneous material that distracts from the cognitive objective of the lesson. Is there a way to add interesting words or graphics that serve to support the instructional goal while at the same time promote interest? Research is needed on how to interest learners and at the same time be sensitive to limits on their cognitive processing capacity.
DESIGN DILEMMA: RESOLVED

In an effort to accommodate younger learners used to high-intensity media, the spreadsheet team considered adding interesting visuals, audio, and words to the basic lesson. The options we considered were:

A. Ben is correct. Adding some interesting words and visuals about spreadsheets will improve interest and learning—especially among younger learners.

B. Reshmi is correct. Learning is better in the presence of soft music, especially classical music.

C. Matt is right. Less is more for most learners.

D. Not sure who is correct.

Based on the evidence presented in this chapter, we vote for Option C. The project manager will be happy because resources needed to create interesting visuals and narrations will not be needed, since evidence suggests their effects are deleterious to learning. Since the evidence for the coherence principle is based on performance of college-aged subjects, we reject the generational argument. We suggest that the team consider other ways to make the lesson engaging, such as using examples and practice exercises that are relevant to the work tasks that learners will face on the job and making the benefits of spreadsheets explicit in the process.

We recommend that you make a distinction between emotional interest and cognitive interest. Emotional interest occurs when a multimedia experience evokes an emotional response in a learner, such as reading a story about a life-threatening event or seeing a graphic video. There is little evidence that emotion-grabbing adjuncts—which have been called seductive details—promote deep learning (Garner, Gillingham, & White, 1989; Renninger, Hidi, & Krapp, 1992). In short, attempts to force excitement do not guarantee that students will work hard to understand the presentation. In contrast, cognitive interest occurs when a learner is able to mentally construct a model that makes sense. As a result of attaining understanding, the learner feels a sense of enjoyment. In summary, understanding leads to enjoyment. The achievement of cognitive interest depends on active reflection by the learner rather than exposure to entertaining but irrelevant sights and sounds.
Overall, the research and theory summarized in this chapter show that designers should always consider the cognitive consequences of adding extraneous sounds, pictures, or words. In particular, designers should consider whether the proposed additions could distract, disrupt, or seduce the learner’s process of knowledge construction.

**WHAT TO LOOK FOR IN e-LEARNING**

- Lessons that *do not* contain extraneous sounds in the form of background music or sounds
- Lessons that *do not* use illustrations, photos, and video clips that may be interesting but are not essential to the knowledge and skills to be learned
- Lessons that *do not* contain interesting stories or details that are not essential to the instructional goal
- Lessons that use simpler visual illustrations such as line drawings when the goal is to help learners build understanding
- Lessons that present the core content with the minimal amount of words and graphics needed to help the learner understand the main points

**COMING NEXT**

We have seen in this chapter that extraneous sounds, graphics, and textual details can depress learning compared to more concise lessons. In the next chapter on the personalization principle, we ask about the learning effects of formal versus informal language in e-lessons and preview an area of emerging research on the benefits of different voices in narration and on the use of virtual coaches.
Suggested Readings

Avoid Adding Extraneous Sounds


Avoid Adding Extraneous Pictures


Avoid Adding Extraneous Words


