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Increased Interestingness of Extraneous Details in a Multimedia Science Presentation Leads to Decreased Learning

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In Experiment 1, students received an illustrated booklet, PowerPoint presentation, or narrated animation that explained 6 steps in how a cold virus infects the human body. The material included 6 high-interest details mainly about the role of viruses in sex or death (high group) or 6 low-interest details consisting of facts and health tips about viruses (low group). The low group outperformed the high group across all 3 media on a subsequent test of problem-solving transfer ($d = .80$) but not retention ($d = .05$). In Experiment 2, students who studied a PowerPoint lesson explaining the steps in how digestion works performed better on a problem-solving transfer test if the lesson contained 7 low-interest details rather than 7 high-interest details ($d = .86$), but the groups did not differ on retention ($d = .26$). In both experiments, as the interestingness of details was increased, student understanding decreased (as measured by transfer). Results are consistent with a cognitive theory of multimedia learning, in which highly interesting details sap processing capacity away from deeper cognitive processing of the core material during learning.

Keywords: interest, seductive details, coherence effect, instructional technology

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To make a scientific lesson more interesting, it might be tempting to add interesting facts or anecdotes that spice up the lesson. For example, for a lesson on how viruses cause colds, you might be tempted to add information about a research study showing that people who regularly engage in sex are less likely to catch colds. For a lesson on how digestion works, you might be tempted to add an anecdote about sword swallowers. Material that is interesting but not relevant to the instructional goal is called a *seductive detail* (Garner, Gillingham, & White, 1989). Research on seductive details has shown that adding seductive details tends to decrease learning from text passages (Garner, Alexander, Gillingham, Kulikowich, & Brown, 1991; Garner, Brown, Sanders, & Menke, 1992; Garner et al., 1989; Wade, 1992) and from multimedia presentations (Harp & Mayer, 1997, 1998; Mayer, Heiser, & Lonn, 2001). The goal of the present study is to better understand how seductive details do their harm by comparing the learning outcomes of students who learn from multimedia lessons containing high-interest versus low-interest details.

Not all extraneous material may be equally interesting so the research question addressed in this study concerns the level of interestingness of the added material: Do students learn more deeply when high-interest adjunct material is added to a scientific explanation than when low-interest adjunct material is added? To address this question, we present learners with a multimedia lesson explaining a cause-and-effect system such as how a virus causes a cold or how people digest food. We insert sentences that are related to the topic but irrelevant to the goal of understanding the cause-and-effect system—which we call *extraneous details* (or *irrelevant details*). The inserted sentences are either high in interest (so they can be considered seductive details) or low in interest (so they cannot be considered seductive details). As you can see, extraneous details (which we also call irrelevant details) can be broken down into high-interest details (which some researchers also call seductive details) and low-interest details (which are not seductive details). Our goal is not to create boring details per se or to demonstrate that adding extraneous details can harm learning as this is already well established. Rather, our empirical goal is to determine how the level of interestingness of the added extraneous details affects the learning outcome and our theoretical goal is to contribute to a theory of how seductive details hurt learning.

We used retention tests to measure how well learners remember the presented explanation (indicating the degree to which they represented the presented material) and transfer tests to measure how well learners are able to use the presented explanation to solve problems (indicating the degree to which they organized and integrated the material with prior knowledge), as proposed by Mayer (2001, 2005).

What Are the Cognitive Consequences of Increasing the Interestingness of Extraneous Details in a Multimedia Science Lesson?

This research is inspired by the cognitive theory of multimedia learning (Mayer, 2001, 2005) and cognitive load theory (Chandler & Sweller, 1991; Paas, Renkl, & Sweller, 2003; Sweller, 1999,

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2005), which propose that learners have a limited amount of processing capacity available during learning. For example, Mayer (2001, 2005) distinguished among three cognitive processes required for building a meaningful learning outcome: *selecting*–paying attention to relevant material and mentally representing it in working memory; *organizing*–mentally organizing the selected information into a coherent cognitive structure; and *integrating*–connecting the new information with existing knowledge from long-term memory. In contrast, *extraneous processing* is cognitive processing that is not directed toward achieving the instructional goal but uses the learner's limited processing capacity. When cognitive processing is used for extraneous processing, less capacity is available for selecting, organizing, and integrating—the cognitive processes involved in meaningful learning.

How do extraneous details hurt learning? Based on the foregoing theory, we entertain two ways that seductive details could create extraneous processing. Extraneous details can cause the learner to engage in extraneous processing mainly because they are interesting and thereby draw the learner's attention (seduction hypothesis) or because they are interspersed within a lesson and thereby disrupt the learner's construction of a mental model (disruption hypothesis). The present study is intended to disentangle these two explanations, and in particular, to determine whether interestingness of the extraneous details is an important factor contributing to the seductive details effect.

According to the seduction hypothesis, high-interest details draw more of the learner's cognitive processing capacity than do low-interest details, thereby leaving less capacity for making sense of the essential material. With less processing capacity available, learners are most likely to cut back on deeper cognitive processing—mentally organizing the material and integrating it with prior knowledge. The seduction hypothesis predicts the high-interest group will perform lower than the low-interest group, particularly on transfer performance (which is intended to tap deep learning).

According to the disruption hypothesis, adding irrelevant sentences—whether high or low in interest—creates equivalent amounts of extraneous processing that disrupts the learner's construction of a coherent mental model. When instructors insert extraneous material in a lesson, learners may have difficulty building connections between relevant steps in the causal chain. The disruption hypothesis predicts no difference between the high-interest group and the low-interest group on retention (which measures acquisition of the presented material) or transfer performance (which measures deeper processing of the presented material) because both groups receive extraneous sentences in the same places in the lesson.

Rationale for Comparing the Effects of Adding High- Versus Low-Interest Details in a Multimedia Science Lesson

Our rationale for comparing the cognitive effects of low- versus high-interest details concerns empirical, theoretical, and practical implications. Concerning empirical implications, there are currently no replicated data that compare the transfer performance of students who learned with low-interest details versus high-interest details in which these details were extraneous to the learning. Previous studies have generally compared retention (or transfer) performance of students who learned with or without seductive details (i.e., high-interest details). Concerning theoretical implications, the present study is the first to enable a test of the idea that the interestingness of extraneous material can have an effect on learning, with more interesting extraneous material creating more extraneous load. Although we do not have a direct measure of extraneous processing, we use transfer test performance as an indirect measure. Concerning practical implications, some authors work hard to have particularly interesting extraneous material such as anecdotes and cartoons, so it is worthwhile to determine the instructional effectiveness of increasing the interestingness of adjunct elements in a lesson.

Advances in the Study of Interest

The study of interest has a long history in educational psychology dating to Dewey's (1913) classic book, *Interest and Effort in Education*. More recently, research on personal interest (or individual interest) has shown that students tend to perform better on learning material that interests them than on material that does not interest them (Ainley, Hidi, & Berndorff, 2002; Hidi & Harackiewicz, 2000; Hidi & Renninger, 2006; Pintrich & Schunk, 2002; Renninger, Hidi, & Krapp, 1992). More important, students also tend to use deeper processing strategies on learning material that interests them than on material that does not interest them (Pintrich & Garcia, 1991; Pintrich & Schunk, 2002).

Research on situational interest also shows some evidence that making a lesson more interesting can improve student learning (Alexander, Kulikowich, & Jetton, 1994; Hidi & Harackiewicz, 2000; Pintrich & Schunk, 2002; Schraw, 1998; Schraw & Lehman, 2001; Wade, Schraw, Buxton, & Hayes, 1993). However, when the added material takes the form of seductive details–interesting but irrelevant statements—student learning can be hurt (Garner et al., 1991, 1992; Harp & Mayer, 1997, 1998; Lehman, Schraw, McCrudden, & Hartley, 2007; Sanchez & Wiley, 2006; Wade, 1992).

In this study, we extend previous research on seductive details in three ways. First, we examine the effects of details that vary in their level of interestingness (i.e., by calibrating the interestingness of the added material) rather than simply the presence or absence of seductive details, which is the approach taken in most other studies. In this way, we can control for the distracting effects of adding material to a lesson and focus on testing the hypothesis that inserting more interesting details would harm learner understanding more than inserting less interesting details. Second, we measure learning in terms of problem-solving transfer and retention rather than solely based on retention of the presented material, which is the approach taken in many other studies. Measures of problem-solving transfer are intended to gauge the learner's understanding. Third, we compare the effects of high-interest and low-interest details using various multimedia contexts including booklets, PowerPoint presentations, and narrated animation, rather than printed text alone. Although most previous research focuses on a paper-based medium, it is worthwhile to determine whether the effects of interestingness of extraneous details are robust across new instructional media as well. In short, the current studies offer a new examination of the role of the interestingness of extraneous material.

Would anyone insert low-interest details into a lesson in actual learning environments? We hope not, but designers may be enticed to insert high-interest details. Our rationale for using low-interest details was to test a theory that predicts that the interestingness of extraneous details has an effect on learning. Using low-interest details allows us to control for the presence of inserted irrelevant material, so that the effects of high-interest details cannot be attributed solely to the fact that they add length to the lesson. In short, low-interest details provide a control treatment to compare against the high-interest treatment.

In this paper we report on two experiments. Experiment 1 involves a lesson about how viruses cause colds and includes a preliminary study in which we calibrated the materials used in Experiment 1. Experiment 2 involves a lesson about how digestion works and includes a preliminary study in which we calibrated the materials used in Experiment 2.

Experiment 1 (Virus Lesson)

In Experiment 1, students studied a multimedia science lesson that explained six steps in how a cold virus infects the human body. The lesson included six high-interest details mainly about the role of viruses in sex or death (high group) or six low-interest details consisting of facts and health tips about viruses (low group). Each version was presented in a booklet as printed text and illustrations, in a PowerPoint presentation as on-screen text and illustrations, or as a narrated animation. Then, all students took retention and transfer tests. The rationale for using three different media was to determine whether the same pattern would be obtained for each one, thereby demonstrating the robustness of the results. Our focus was not on comparing different media, but rather on examining whether the same instructional effects occurred across media.

Preliminary Study

The purpose of the preliminary study was to calibrate the interestingness of a collection of statements about viruses to be used in Experiment 1. The participants were 34 college students enrolled in an introductory psychology course at the University of California, Santa Barbara. Seventeen participants received one ordering of items in the questionnaire and 17 received the reverse ordering. The materials consisted of six-page questionnaires, printed on 8.5 × 11 in sheets of paper, which listed 38 statements about viruses taken from a wide assortment of noncopyrighted websites, pamphlets, and books. Participants were asked to write a number from 1 to 7 next to each statement based on the scale: 1 (*very boring*), 2 (*somewhat boring*), 3 (*slightly boring*), 4 (*neutral*), 5 (*slightly interesting*), 6 (*somewhat interesting*), 7 (*very interesting*). The order of the 38 items in one of the questionnaires (Form A) was reversed in the other questionnaire (Form B). We computed mean ratings for each of the 38 statements. The top section of Table 1 shows one of the six highest rated statements (i.e., high interest), and the second section of Table 1 shows one of the six lowest rated statements (i.e., low interest). The entire set of all extraneous statements can be found in Supplementary Materials. Overall, the results allow us to identify the 6 most interesting statements—which mainly concern sex and death—and the six least interesting statements—which mainly concern gratuitous facts and health tips—for use in Experiment 1. Statements about sex and death have been suggested to be inherently interesting (Kintsch, 1980), but this study provides an empirical test of that conjecture.

Table 1
Examples of Materials Used in Experiment 1 (Virus Lesson)

High-interest statement (n = 6)
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.
Low-interest statement (n = 6)
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 1,000 times smaller than a human hair.
Retention test (n = 1)
Based on the lesson you just read, describe how a cold virus attacks the body.
Transfer test (n = 5)
Suppose you are exposed to a cold virus from an infected person who sneezes on you, but you do not get sick. Why not?
If you could, how would you change the human body to minimize the chances of viral infection?
What would happen to viruses if the cells in our bodies developed thicker membranes?
What do cell membranes have to do with viral infection? What do cell enzymes have to do with viral infection? What does DNA have to do with viral infection?
Why do some kinds of viruses kill their hosts whereas other kinds do not?

Participants and Design

The participants were 89 college students enrolled in an introductory psychology course at the University of California, Santa Barbara. For the booklet version, 14 students served in the low group and 16 served in the high group; for the PowerPoint version, 14 students served in the low group and 15 served in the high group; for the narrated animation version, 15 students served in the low group and 15 served in the high group. Overall, the mean age was 19.2 years (SD = 1.3), and there were 30 men and 59 women. All participants indicated low prior knowledge of biology on a questionnaire, and there were no differences between the groups.

Materials and Apparatus

The materials common to all participants consisted of a participant questionnaire, retention test sheet, and five transfer test sheets. The participant questionnaire solicited basic demographic information and information concerning the participant's knowledge of human biology. The retention test sheet contained the question shown in the third section of Table 1 and the transfer test sheets each contained one of the questions listed in the bottom of Table 1. The bottom of each retention and transfer sheet had the following instructions: "PLEASE KEEP WORKING UNTIL YOU ARE ASKED TO STOP." The transfer questions are examples of four problem types (Mayer, 2001): *troubleshooting*–asking why the system does not work, *redesign*–asking for a redesign of a system for a different purpose, *what-if*–asking what would happen under certain conditions, and *principle*–asking about the role of a component or why a component behaves as it does. The transfer questions require *problem-solving transfer*–a form of transfer in which the learner uses what was learned to solve new problems (Mayer & Wittrock, 2006). They constitute near transfer because learners are asked to apply the learned material within the same domain it was learned.

For the booklet version, there were two instructional booklets. Each of the two instructional booklets consisted of a three-page folder containing a page of text on the left, an illustration in the middle, and a page of text on the right. All pages were typed in black ink on white 8.5 × 11 in sheets of paper, with 12-point Times font. All booklets contained the title, "How a Cold Virus Attacks the Body" at the top of the first page.

The core of the booklet contained 500 words—broken into eight paragraphs—explaining the steps involved when a virus infects the human body. The first two paragraphs described what a virus is and how a virus is different than a cell. Each of the last six paragraphs described a step in the process of infection. Above each of these paragraphs was a heading indicating the step in the process: "Entering the Body," "Attaching to the Host Cell," "Injecting the Genetic Material into the Host Cell," "Copying the Virus' Genetic Code," "Breaking Free from the Host Cell," and "Spreading Throughout the Body." The core text of the booklet is shown in Table 2. The booklet also contained an illustration depicting the six steps in the process of infection, as shown in Figure 1. The low-interest booklet was created by inserting the six low-interest statements (as exemplified in Table 1) into the last six paragraphs of the booklet, with one statement inserted into each paragraph. The high-interest booklet was created by inserting the six high-interest statements (i.e., as exemplified in Table 1) into the last six paragraphs of the booklet, with one statement inserted into each paragraph. The six low-interest statements averaged 42 words per statement (for a total of 249 additional words) whereas the six high-interest statements averaged 44 words per statement (for a total of 262 additional words). The extraneous details were inserted within existing paragraphs at points in the lesson in which they were thematically related, and they were not explicitly highlighted as extraneous.

For the PowerPoint version, there were two PowerPoint presentations identical in content to the low-interest and high-interest booklets, respectively. Each presentation consisted of eight slides, each containing one of the eight paragraphs from the booklet. The final six slides also contained the relevant illustration (on the right side), with the current step highlighted. Participants could view the presentation by using the arrow keys on the keyboard to move forward and backward through the slides. The apparatus consisted of five Macintosh i-book laptop computers with 15-inch screens.

For the narrated animation version, there were two Flash programs with verbal scripts that were identical to the low-interest and high-interest booklets, respectively. The narration was spoken at a slow pace in a male voice, and was coordinated with events depicted in the animation. The appropriate extraneous details were incorporated as spoken words in the narration, with the low-interest version containing the words from the low-interest booklet and the high-interest version containing the words from the high-interest booklet. Each program contained the same animation, which depicted the six steps in the process of viral infection based

Table 2
A Text on "How A Cold Virus Attacks The Body"

What is a virus?

A virus particle is a tiny package consisting of a set of genetic instructions in the form of DNA and RNA and a protein coating that surrounds and protects the genetic instructions. Some viruses—called enveloped viruses—are surrounded by a lipid membrane similar to the membrane surrounding cells, whereas other viruses—called naked viruses—have no lipid membrane.

How is a virus different from a cell?

Living cells—in animals, plants, and even bacteria—contain everything they need to function. That is, cells contain all the enzymes needed to carry out the chemical reactions needed to maintain life and to reproduce themselves. A virus does not have all of these components, and thus is not able to function on its own. Instead, viruses carry only one or two enzymes that can begin the process of decoding their genetic code. A virus must have a host cell—an animal cell, a plant cell, or a bacterium—in which to live and make more viruses. Outside a host cell, viruses cannot function and can only exist in a dormant state for a short time.

What are the steps in a catching a cold?

Step 1: Entering the body

A cold virus can enter the human body through the nose or mouth or a break in the skin. Once it finds its way inside a person, it searches for a host cell to infect. Usually, cold viruses attack cells that line the respiratory or digestive tracts.

Step 2: Attaching to a host cell

A virus uses a type of protein on its outside coat or envelope that recognizes a proper host cell, and then the virus attaches itself to the targeted host cell. Some enveloped viruses dissolve right through the host's cell membrane, which is made of lipid like the virus's envelope.

Step 3: Injecting genetic material into the host cell

Once attached to the host cell, a virus injects its genetic instructions into the cell through the cell membrane. Enveloped viruses simply release their contents when they get inside.

Step 4: Copying the virus's genetic code

The injected genetic material recruits the host cell's enzymes to help copy the virus's genetic material. Thus, the host cell's enzymes produce parts, such as genetic instructions and proteins, for making more virus particles.

Step 5: Breaking free from the host cell

The new parts are packaged into new viruses within the host cell. The new viruses break free from the host cell. In some cases, they break the host cell open, destroying the host cell in the process, which is called lysis. In other cases they, pinch out of from the cell membrane and break away with a piece of the cell membrane surrounding them, which is called budding.

Step 6: Spreading throughout the body

When it is free of the host, the new virus can attack other cells. Because one virus particle can reproduce thousands of new copies of itself, viral infections can spread quickly throughout the body. Now the person has a cold.

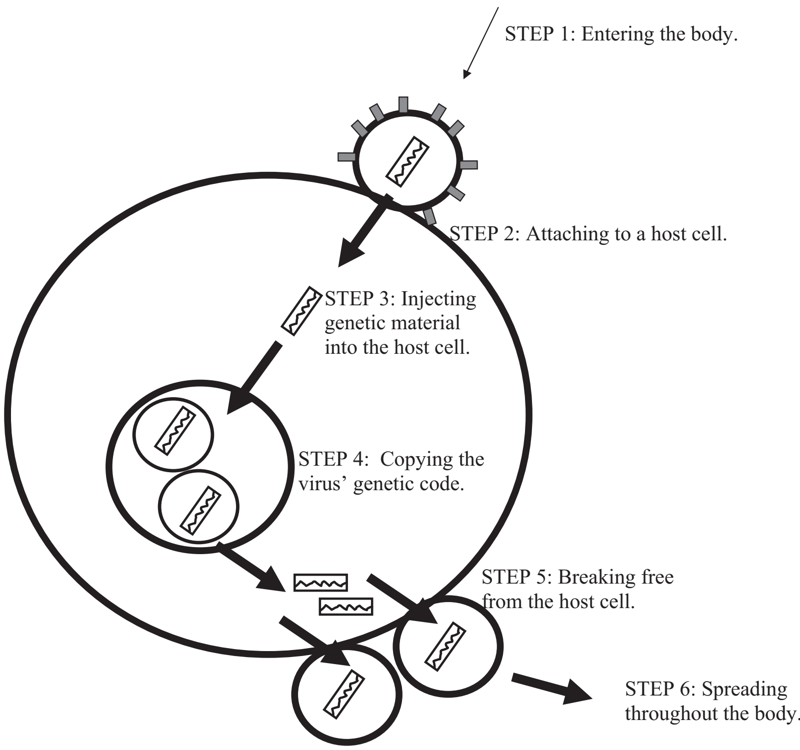

Figure 1. Illustration depicting six steps in how a cold virus infects the human body.

on animating the black-and-white line drawing used in the booklet. Each Flash program ran for 6 min and was not under learner control. The apparatus consisted of five Sony Vaio laptop computers with 17-inch screens and Panasonic headphones.

Procedure

The participants were tested in groups of up to five students per session, with each participant seated in a separate cubicle. The booklet version, PowerPoint version, and narrated animation version were administered during different academic quarters across an academic year. Within each version, the participants were randomly assigned to one of the two treatment groups—low interest or high interest.

First, the participants signed an informed consent form. Second, they filled out the participant questionnaire at their own rate.

Third, for the booklet version the experimenter informed the participants that they would be reading a passage about how viruses infect the body. They were told to read carefully to find out how viruses cause colds, and that after they had finished they would be asked a series of questions about how viruses cause colds. They were informed they would have 5 min to read the booklet. Then, each participant was given a booklet containing low-interest details (for the low group) or high-interest details (for the high group), and was told to begin reading.

The procedure was identical for the PowerPoint version, except that the students had 5 min to view a PowerPoint presentation on a Macintosh i-book laptop computer rather than read a booklet. Students controlled the presentation by pressing the forward arrow to go on to the next slide or backward arrow to go back to a previous slide.

The procedure was identical for the narrated animation version except the students were instructed that they would they would view and listen to a narrated animation about how viruses infect the body. Participants were asked to put on headphones and wait for the experimenter to start the presentation on a Sony Vaio laptop computer. Each presentation lasted 6 min, and could not be controlled by the learner. We did not allow learner control because we wanted to use the conventional format for narrated animation and because learner control can increase extraneous processing for inexperienced learners (Mayer, 2001).

Fourth, after 5 min, the booklets were collected (for the booklet version) or the PowerPoint presentation was terminated and the laptop computer was closed (for the PowerPoint version), or after the 6-min narrated animation ended the experimenter closed the laptop computer and asked the participant to remove the headphones (for the narrated animation version). Then, each participant was given the retention test. Participants were told they would have 4 min to write an answer, and after 4 min the retention sheets were collected.

Fifth, the participants were given the five transfer sheets, one at a time, for 2.5 min per sheet. The sheets were distributed in the order described in the materials and apparatus subsection. As each sheet was given, the participants were instructed to write down their answer on the sheet and were reminded that they would have "two and a half minutes." After the participant spent 2.5 min on one sheet, it was collected and the next one was handed out. After the fifth sheet has been collected, the participants were thanked and debriefed. The entire session lasted approximately 30 min.

Results and Discussion

Scoring and analysis. The retention test and transfer test were scored by raters who were blind to the condition, including a professor and an advanced graduate student in psychology. A subset of 20 tests was scored by two raters, yielding an interrater reliability of $r = 1.00$ on the retention test and $r = .94$ on the transfer test. Disagreements were resolved by consensus. No partial credit was awarded. Points were not deducted for errors; if part of a sentence contained a correct answer and part contained an incorrect answer, the participant received credit for the correct answer.

The retention test was scored by determining how many of 13 key ideas units were included in the response, yielding a possible score ranging from 0 to 13. One point was given for each idea unit, regardless of wording.

The transfer test of each participant was scored by assigning 1 point for each acceptable answer written by the participant across all five questions, yielding a possible score ranging from 0 to 18. To aid in scoring, a list of acceptable answers was generated for each question, based on consultation with an expert in biology. For example, for the question asking how the human body could be changed to minimize the chance of viral infection, acceptable answers included limiting openings so that the virus can't get in the body or changing the cell membrane so that the virus can't penetrate.

Table 3 shows the mean number correct (and standard deviation) for each group within each of three presentation versions on the transfer and retention tests. For each test, we conducted an analysis of variance with group (low or high) and version (booklet, PowerPoint, or narrated animation) as between subject factors.

Table 3
Mean Scores (and Standard Deviations) on Transfer and Retention Tests for Two Groups With Three Media—Experiment 1 (Virus Lesson)

	Level of interest of extraneous details				
	Low		High		
Test measure and presentation medium	*M*	*SD*	*M*	*SD*	*d*
Transfer score					
Booklet	5.0	2.2	4.1	2.1	0.42
PowerPoint	7.3	2.6	4.9	2.0	1.04
Narrated animation	5.4	2.4	3.3	1.4	1.10
Total	5.9[a]	2.4	4.1	1.9	0.80
Retention score					
Booklet	6.5	2.2	6.1	2.1	0.19
PowerPoint	6.4	2.5	6.3	2.0	0.04
Narrated animation	4.9	1.2	4.9	1.1	0.00
Total	5.9	2.4	5.8	1.8	0.05

Note. For booklet medium, $n = 30$; for PowerPoint medium, $n = 29$; for narrated animation medium, $n = 30$.
[a] Indicates low group scored significantly higher than high group on transfer score.

What are the cognitive consequences of inserting low-interest versus high-interest details into a multimedia science lesson? According to the cognitive theory of multimedia learning, students receiving low-interest details should perform better on the transfer test than students receiving high-interest details. The top portion of Table 3 shows that the mean transfer score of the low group was significantly greater than the mean transfer score of the high group, $F(1, 83) = 17.90$, $MSE = 4.05$, $p < .001$. The effect size is $d = .80$, which is considered a large effect. This result is consistent with the cognitive theory of multimedia learning.

More important, there was no significant interaction between treatment group and presentation version, $F(2, 83) = 1.09$, $MSE = 4.05$, $p > .20$, indicating that the group effect favoring the low group was consistent across all three presentation versions. The effect size favoring the low group was $d = .42$, for the booklet version, $d = 1.04$, for the PowerPoint version, and $d = 1.10$, for the narrated animation version.

As you can see in the bottom portion of Table 3, the mean retention scores of the low group and high group did not differ significantly, $F(1, 83) = .148$, $MSE = 3.61$, $p > .20$. The effect size is $d = .05$, which is considered a negligible effect. More important, there was no significant interaction between treatment group and presentation version, $F(2, 83) = .137$, $MSE = 3.61$, $p > .20$, indicating that lack of a group effect between the low and high groups was consistent across all three presentation versions. The effect size favoring the low group was $d = .19$, for the booklet version, $d = .04$, for the PowerPoint version, and $d = .00$, for the narrated animation version, all of which are considered negligible effects. This result is not inconsistent with the cognitive theory of multimedia learning, and suggests that students had sufficient cognitive capacity to mentally represent key elements of the presentation.

Overall, the pattern of results is most consistent with the idea that increasing the interestingness of extraneous details from low to high tends to have no effect on paying attention to and representing the main ideas, but tends to decrease deeper processing aimed at mentally organizing and integrating the main ideas. Although we did not have a direct measure of cognitive processing during learning, we used test performance on retention and transfer as indirect measures. It is worthwhile to note that these results control for adding additional content to the lesson—as in both treatments we added six statements—so the main focus is on the level of interestingness of the added statements. In summary, increasing the interest value of extraneous details does not appear to distract learners from attending to the main ideas in the lesson (as indicated by retention test performance), but it does disrupt their cognitive activity aimed at building a coherent mental model of the to-be-learned system (as indicated by transfer test performance). More important, the same pattern was observed for each of the three presentation versions, indicating that the effects of increasing the interestingness of extraneous details work the same way across different educational media.

Experiment 2 (Deglutition Lesson)

In Experiment 1, there was a pattern in which the low group outperformed the high group on transfer but not retention, consistent with the predictions of the cognitive theory of multimedia learning. Experiment 2 was performed to determine whether this pattern of results could be replicated using different materials—a multimedia PowerPoint lesson explaining the process of deglutition (i.e., swallowing during digestion). Experiment 1 could be criticized on the grounds that students had a limited amount of time for the lesson, so students in Experiment 2 were free to study the lesson at their own pace. We used a PowerPoint format in Experiment 2 because PowerPoint was an effective medium in Experiment 1, it is a common medium for presenting multimedia material, and it is convenient to use. We focused on a lesson that explains a cause-and-effect system because the cognitive theory of multimedia learning is concerned with the process of mental model construction.

Preliminary Study

The purpose of the preliminary study was to calibrate the interestingness of a collection of statements about swallowing and digestion, which were used in Experiment 2. The participants were 27 college students enrolled in an introductory psychology course at the University of California, Santa Barbara. Thirteen participants received one ordering of statements in a questionnaire, and 14 received the reverse ordering. The materials consisted of two four-page rating questionnaires that contained 56 short statements related to swallowing or digesting, taken from free-access sources found through online searches. Both questionnaires contained the same statements, but the statements were listed in the reverse order from one another. Participants were asked to write a number from 1 to 7 next to each statement based on the following scale: 1 (*very boring*), 2 (*somewhat boring*), 3 (*slightly boring*), 4 (*neutral*), 5 (*slightly interesting*), 6 (*somewhat interesting*), 7 (*very interesting*). We calculated the average rating for each of the 56 statements. The seven highest rated statements, one of which is shown in the top of Table 4, tended to be disgusting or life threatening. The seven lowest rated statements, one of which is shown in the second section of Table 4, tended to contain number facts. The complete list of extraneous statements is available in Supplemental Materials.

Table 4
Examples of Materials Used in Experiment 2 (Digestion Lesson)

High-interest statement (n = 7)
The majority of sword swallowers employ a guiding tube, which they have previously ingested and hence their performances are less dangerous.
Low-interest statement (n = 7)
Hundreds of different kinds of enzymes are needed to properly digest food.
Retention test (n = 1)
Describe the steps involved in deglutition.
Transfer test (n = 5)
Suppose you put food in your mouth, but it does not wind up in your stomach. What could have gone wrong?
How can you redesign the mouth and esophagus to speed the process of deglutition?
When a person says, "It went down the wrong pipe," to what are they referring?
Is it possible to swallow while standing on your head? If so, how is it possible?
What would happen to the process of deglutition if the connection between the nasal cavity and the trachea could not be blocked?

Participants and Design

The participants were 53 college students enrolled in an introductory psychology course at the University of California, Santa Barabara. Twenty-seven students served in the low group and 26 served in the high group. The mean age was 18.8 years (SD = 1.1), and the sample consisted of 13 men and 40 women. All participants indicated low knowledge of human physiology on a questionnaire, and there were no differences between the groups.

Materials and Apparatus

The paper-based materials consisted of a participant questionnaire, retention test sheet, and five transfer test sheets, each printed on 8.5 × 11 in sheets of paper. The participant questionnaire solicited demographic information and information concerning the student's experience with human physiology. The retention test sheet contained the question in the third section of Table 4 and the transfer test sheets each contained one of the questions shown in the bottom of Table 4. At the bottom of each retention and transfer test sheet was the statement: "PLEASE KEEP WORKING UNTIL YOU ARE ASKED TO STOP."

The computer-based materials consisted of two PowerPoint presentations that described steps in the process of deglutition—one with high-interest statements inserted throughout and one with low-interest statements inserted throughout. Both presentations consisted of 18 PowerPoint slides, with each slide containing a heading at the top, a labeled line drawing on the right side, and several sentences of text on the left side. An example slide is shown in Figure 2. Both presentations contained the same headings, line drawings, and core text. The headings described the slide in one or two words, such as "Swallowing Food," "The Tongue," and "Mastication." The line drawings depicted the part of the digestive system being described in the text—such as the mouth, the upper part of the digestive tract, and the lower part of the digestive tract—along with labels for parts mentioned in the text—such as bolus, epiglottis, trachea, and esophagus. The core text described the steps in deglutition, including the teeth chewing the food, the tongue pushing the bolus to the back of the mouth, the pharynx transporting the food from the mouth to the esophagus, and so on. The core text consisted of 585 words, and there were an additional 50 words in the labels to the line drawings, yielding a total of 635 words common to both presentations. The core text for the 18 slides is shown in Table 5.

The high-interest presentation also contained seven additional high-interest statements (exemplified in the top of Table 4) that were inserted on Slides 1, 4, 6, 8, 10, 13, and 16. The low-interest presentation also contained seven additional low-interest statements (exemplified in the second section of Table 4) that were inserted on Slides 1, 4, 6, 8, 10, 13, and 16. The statements were placed after the core text within the same paragraph, and were thematically related to the core text. The seven high-interest statements contained 235 words, whereas the seven low-interest statements contained 107 words. We used the seven highest rated statements and seven lowest rated statements from the preliminary study, but to compensate for differences in lesson length and to be able use study time as a dependent measure we allowed students unlimited time to read the lesson. The apparatus consisted of 5 Macintosh i-book laptop computers with 15-inch monitors.

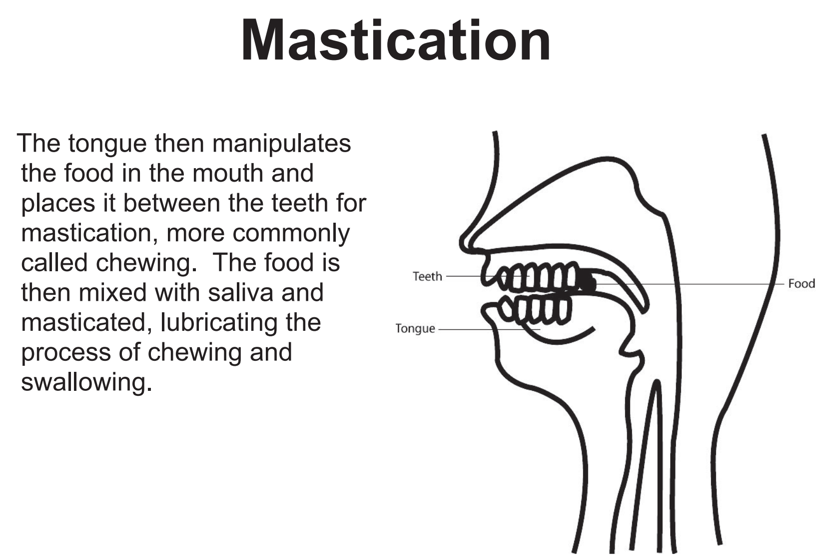

Figure 2. Slide from PowerPoint presentation on the steps in digestion.

Procedure

The procedure was identical to Experiment 2, except that the students had unlimited time to view a PowerPoint presentation on a Macintosh i-book laptop computer. Students controlled the presentation by pressing the forward arrow to go on to the next slide or backward arrow to go back to a previous slide.

Results and Discussion

Scoring and analysis. The scoring procedure was the same as in Experiment 1. A subset of 20 tests was scored by two raters, yielding an interrater reliability of $r = .96$ for the retention test and $r = .96$ for the transfer.

The retention test was scored by determining how many of 23 key ideas units were included in the response, yielding a possible score ranging from 0 to 23. One point was given for each of the ideas units, regardless of wording.

The transfer test of each participant was scored by assigning 1 point for each acceptable answer written by the participant across all five questions. To aid in scoring, a list of acceptable answers was generated for each question. For example, for the question about redesigning the mouth and esophagus, acceptable answers included more teeth, larger tongue, faster-acting saliva, quicker closing epiglottis, quicker closing soft palate, shorter or wider throat, faster moving upper sphincter, shorter or wider esophagus, faster-moving lower sphincter, and separate systems for breathing and swallowing.

Table 6 shows the mean number correct (and standard deviation) for each group on the transfer and retention tests. We conducted *t* tests comparing the two groups on the transfer test score and the retention test scores.

What is the cognitive consequence of inserting low-interest versus high-interest details into a science lesson? According to the cognitive theory of multimedia learning, students receiving low-interest details should perform better on the transfer test than students receiving high-interest details. The top row of Table 6 shows that the mean transfer score of the low group was significantly greater than the mean transfer score of the high group, $t(51) = 3.04$, $p < .01$. $d = .86$. This result replicates Experiment 1 and is consistent with the cognitive theory of multimedia learning.

As you can see in the bottom row of Table 6, the mean retention scores of the low group and high group do not differ significantly, $t(51) = 1.05$, $p > .20$, $d = .26$. This result replicates Experiment 1.

Overall, the pattern of results replicates that of Experiment 1—the low group outperformed the high group on transfer but not retention. This pattern is consistent with the cognitive theory of multimedia learning, and the idea that increasing the interestingness of extraneous details decreased the learner's resources for engaging in deep cognitive processing during learning.

Do the groups differ in study time? Both groups received the same number of slides, each with a heading and a labeled illustration, and both groups received the same core of 635 words. However, the seven added statements totaled an additional 235 words for the high group compared to an additional 107 words for the low group. We accepted this confound on the grounds that we wanted to use the seven highest rated statements and the seven lowest rated statements from the preliminary study. In short, highly interesting details may be inherently longer, at least in the case of deglutition. To compensate for the differences in lesson length, we allowed students to study the lesson for as long as they needed. As expected, the high group spent significantly more time with the lesson ($M = 468.1$ s, $SD = 141.5$ s) than the low group ($M = 362.7$ s, $SD = 84.9$ s), $t(51) = 3.30$, $p < .01$, $d = .94$. This finding suggests that both groups had ample time to study all parts of the lesson. In addition, the groups did not differ on retention of the core material, indicating that both groups were equivalent in attending to the core material.

Conclusions

Empirical Findings

What are the cognitive consequences of making extraneous details more interesting? Specifically, what happens when

Table 5
Core Text For Each of 18 Slides Used In Experiment 2

Swallowing food.
The digestive journey commences in the mouth. Food is voluntarily moved to the rear of the oral cavity (mouth), but once the food reaches the back of the mouth the reflex to swallow cannot be retracted.
The tongue.
The tongue is secured to the floor of the mouth, and is used in the movement and tasting of the food. Tiny onion-like sensory structures, called taste buds, enable you to taste food.
Mastication.
The tongue then manipulates the food in the mouth and places it between the teeth for mastication, more commonly called chewing. The food is then mixed with saliva and masticated, lubricating the process of chewing and swallowing.
The bolus.
The food is gradually chewed, creating a moist mass called a bolus. The bolus is now ready to be swallowed.
Swallowing.
The tip of the tongue now pushes on the roof of the mouth at the hard, front section of the palate. The palate is a shelf-like plate at the top of the mouth, dividing the nasal and oral cavities.
Swallowing.
The bolus gets trapped behind the tongue, as the tongue body rises from the front to push the bolus to the back of the mouth. The bolus begins to travel down and into the pharynx (throat).
The throat.
The pharynx transports the food from the mouth to the esophagus (gullet). Simultaneously, the epiglottis (a piece of tissue connected to the windpipe) lifts and seals the passage to the trachea (windpipe).
The throat.
A bolus entering the top of the trachea causes choking and possible asphyxiation. Breathing is also temporarily inhibited as the bolus travels passed the trachea and into the esophagus.
The throat.
The bolus reaches the pharynx, and the rear and soft part of the palate lifts up to block the passage into the nasal cavity.
Swallowing.
Muscular activity in the pharynx creates a waving motion and massages the bolus down into the esophagus.
The esophagus.
The upper esophageal sphincter, located at the start of the esophagus, relaxes and opens when the bolus approaches the esophagus.
Painful swallowing.
Painful swallowing is usually caused by inflammation of the esophagus, and a tense esophageal sphincter.
Peristalsis.
Snake-like writhing movements, a process called peristalsis, progressively pushes the bolus through the esophagus. The bolus now travels down towards the stomach.
Peristalsis.
Reverse peristalsis can be initiated, causing the contents of the stomach to travel up the esophagus and be thrown out of the mouth with surprising force. This process, also called vomiting, rids the digestive system of bad foods, poisons, or excessive contents.
The esophagus.
The lower esophageal sphincter, located at the end of the esophagus, relaxes and opens to allow the bolus into the stomach. Immediately after the passage of the bolus, the sphincter closes again to prevent reflux of gastric juices.
The esophagus.
If gastric juices or food materials leak and move up the esophagus, a sensation known as heartburn occurs in the body. Hundreds of different kinds of enzymes are needed to properly digest food.
The stomach.
The stomach is a very flexible muscle, varying in both shape, size, and capacity. Any lump of food or bubbly gas in the central space of the stomach (lumen) stretches the inner walls. The stomach serves as a temporary reservoir for the ingested foods and liquids.
The stomach.
The stretching of the stomach then initiates the contraction of the muscle behind the bolus, pushing the food into the next digestive segment – the small intestine.

we spice up a multimedia science presentation with high-interest material rather than low-interest material that is related to the content of a lesson but does not support the instructional goal? This set of experiments is the first to examine this question. In the present experiments, we obtained consistent results: adding high-interest details to a lesson resulted in poorer transfer test performance than adding low-interest details, and both groups performed at equivalent levels on retention tests. The same pattern was obtained across three different presentation media in Experiment 1 as well as with different content in Experiment 2. The effect size favoring the low group on transfer was in the large range ($d = .8$) in both Experiment 1 and Experiment 2.

Theoretical Implications

Overall, the results contribute to the cognitive theory of multimedia learning (Mayer, 2001, 2005) and cognitive load theory (Chandler & Sweller, 1991; Sweller, 1999). In particular, the pattern of results is consistent with the seduction hypothesis—the idea that learners engage in more extraneous processing for lessons containing high-interest extraneous material than low-interest extraneous material, thereby leaving less cognitive capacity for deep cognitive processing of the essential material during learning. The results are inconsistent with the disruption hypothesis, which predicts that the high and low groups would perform at the same level on measures of learning

Table 6
Mean Scores (and Standard Deviations) on Transfer and Retention Tests for Two Groups—Experiment 2 (Digestion Lesson)

	Level of interest of extraneous details				
	Low		High		
Test measure	*M*	*SD*	*M*	*SD*	*d*
Transfer score	7.9[a]	2.6	5.7	2.5	.86
Retention score	7.3	2.5	6.7	2.2	.26

Note. All lessons were in PowerPoint medium; $n = 53$.
[a] Indicates low group scored significantly higher than high group on transfer score.

because adding any kind of extraneous material disrupts the learning process.

We used transfer test performance as an indication of deeper cognitive processing during learning. If we had based our assessment of learning outcomes solely on retention test performance—as is commonly done in seductive details studies—we would have been left with somewhat inconclusive results. The most important new contribution of this study is support for the prediction that the level of interestingness of added material affects transfer test performance. Even when we control for the fact that extraneous material was added to a lesson, more interesting extraneous material harmed learner understanding more than did less interesting extraneous material—as measured by transfer test performance. This work is the first to suggest that increasing the level of interestingness of extraneous material in a lesson can decrease the level of the learner's deep processing of the core material in a multimedia presentation.

Practical Implications

On the practical level, searching for ways to increase the interestingness of extraneous material is not a good strategy when the instructional goal is to promote deep understanding of the presented material. The results suggest instructional designers should refrain from attempts to increase learner understanding by seeking ever more interesting extraneous details. This recommendation contradicts the common practice of inserting highly interesting anecdotes and cartoons in science lessons.

A rationale for adding highly interesting extraneous material is that it can increase the learner's motivation to learn the core material. Under some circumstances, adding highly interesting details (which also are called seductive details) may improve student learning, such as when the added details cause the learner to study harder and when the added details are used sparingly. Further research is needed to pinpoint the conditions under which highly interesting extraneous details could improve student learning.

Limitations and Future Directions

Interpretation of the results of our experiments is subject to several important limitations. First, the studies took place in laboratory contexts, involved college students, used short presentations, and employed an immediate test. Although the studies allowed for well-controlled tests of basic theories of the cognitive effects of interestingness, the robustness of the effects also should be examined in more authentic learning environments. We do note, however, that the extraneous details we used were authentic in the sense that they were obtained from existing web sites rather than made up by the experimenters. We also note that the scientific content of the presentation—explaining the steps in how a virus causes a cold or explaining the steps in the process of digestion—are examples of cause-and-effect explanations that represent a central instruction goal in science education.

Second, there were no independent measures of the level of learner interest or the level of learner cognitive processing during learning. Instead, we made inferences about cognitive processing during learning based on retention and transfer test performance. Although this is an accepted practice in our field, we would welcome new tests of our theories in future studies that include direct measures of cognitive processing during learning.

Third, although we based our selection of high and low interest details on independent student ratings, objections may be raised to the way we controlled for other variables. In both experiments we controlled for the presence of extraneous material—that is, both the high and low groups had the same number of extraneous details inserted in the same places in the lessons—and in Experiment 1 we controlled for the length of the extraneous details in terms of overall number of words. However, in Experiment 2, the seven high-interest details were longer than the seven low-interest details. We opted to use the seven highest rated and seven lowest rated details, with the recognition that sometimes the most interesting details are also the longest. We allowed learners unlimited study time as a way of compensating for differences in the number of words in the lessons, and we found that the groups were equivalent on subsequent retention of the material. Although, Experiment 2 presents results consistent with the cognitive theory of multimedia learning, this conclusion would be strengthened by further research in which the low-interest and high-interest details are equated for length. In addition, future research should examine whether the high and low interest details systematically vary along other dimensions such as concreteness and familiarity.

Although future research is warranted, the experiments presented in this paper offer some advances over previous research on seductive details. First, the experiments focused on the cognitive effects of the level of interestingness of the details (high interest vs. low interest) rather than the presence or absence of seductive details. This methodology allows us to test new aspects of theories concerning how people process words and pictures in a multimedia lesson. Second, the experiments measured learning by using both transfer and retention tests, rather than retention alone. This methodology allows us to measure learning outcomes in terms of depth of understanding rather than simply amount remembered. Third, the experiments involved instruction presented on a computer (i.e., PowerPoint presentations and narrated animations) and on paper (i.e., booklets) rather than paper-based material alone. This methodology allows us to determine whether the effects are robust across various presentation media.

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