MULTIMEDIA DESIGN & COGNITIVE LEARNING THEORY

EFFECTIVE USE OF TEXT AND IMAGES IN MULTIMEDIA INSTRUCTION BASED ON COGNITIVE LEARNING THEORY

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ABSTRACT

This thesis discusses two experiments that investigated the effective use of text and images in multimedia instruction. Experiment 1 examined efficient methods of multimedia design based on theoretical principles concerning how words and images influence information processing. Computer-based lectures were presented to university students containing visual elements including redundant text, non-redundant text, images, and the speaker's image. Lectures with redundant text and audio produced poorer comprehension in comparison to lectures with non-redundant text and images. Non-redundant text and images enhanced learning, and accurate assessments of understanding. Experiment 2 implemented a more controlled design using four computer-based lectures with only two variable manipulations: text (redundant vs. non-redundant) and image (present vs. absent). The speaker's image was removed from the design in Experiment 2 due to its lack of influence on learning in Experiment 1. Redundant text lectures produced the poorest comprehension, but only when images were absent. Contrary to common belief, these experiments demonstrate that redundant text is not an effective visual aid. Additionally, this thesis discusses future research investigating cognitive explanations for text and image effects in multimedia learning.

ACKNOWLEDGEMENTS

The author would like to thank her supervisor Dr. Joseph A. Kim, and members of her graduate supervisory committee: Dr. David Shore, and Dr. Bruce Milliken, for their guidance on experimental design, analysis, write-up, and editing. A special thanks goes to Jennifer Heisz and Faria Sana for invaluable contributions to methodological design and statistical analyses, and to Chris McAllister and Greg Atkinson for help with multimedia design.

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DECLARATION OF ACADEMIC ACHIEVEMENT

The current thesis was achieved through collaboration with supervisory committee members, and knowledgeable professionals in experimental design and statistical analysis.

General Introduction

Multimedia instruction uses words and images to facilitate learning, and has become increasingly prevalent in educational settings (Mayer, 2009). Effective multimedia instruction promotes building mental representations of information from presented words and images. Traditional verbal lectures are often complemented, or even substituted, by a combination of multimedia communication including PowerPoint slides, online delivered audio and visual components, poster presentations, and other media to transfer knowledge. Supplementing traditional lectures with multimedia additions enhances visualization of different mechanisms, such as how brakes work, and can highlight important processes in anatomy, physics, and other disciplines through signaling and visual cueing. Most importantly, multimedia allows information to be delivered as both narration and animation, allowing learners to process information at both verbal and visual levels for maximal understanding (Mayer, 1989; Mayer 1992; Mayer & Anderson, 1992; Levie & Lentz, 1982; Krueger & Schar, 2000; Craig, Gholson, Driscoll, 2002; Kaye & Nicholson, 1992).

Only recently have researchers set out a thorough and empirically grounded analysis of effective multimedia components from a cognitive perspective. A common belief about valuable instruction is that abundant information is always. This thesis takes a cognitive load perspective, with an emphasis on limited working memory capacity, to examine beneficial use of text and images in multimedia instruction. It also applies approaches from the existing literature to a real educational environment in a Canadian university increasing its external validity.

Prior to technological advances in computer-generated graphics and animations, the primary mode of transferring ideas in university settings was through lectures and printed texts (Mayer, 2009). Educational psychologists in the past two decades have explored the benefits and detriments of traditional and multimedia methods (Schwier, Misanchuk, 1993; Mayer, 2009; Powers, 1997; Kaye & Nicholson, 1992). For example, providing information on electric lightning production was significantly less effective when participants read a 500-word text passage, rather than viewed a multimedia lesson (Harp & Mayer, 1998). Learning significantly increased with simple illustrations, or computer-based narrated animations rather than written text alone. Similar learning efficacy was demonstrated with multimedia presentations on how brakes and pumps work, and how plants grow (Mayer & Anderson, 1992; Moreno, Mayer, Spires, Lester, 2002). In addition, student performance was enhanced when multimedia instruction addressed difficult theoretical and conceptual notions in teaching dentistry (Salajan et al, 2009).

Importantly, all aforementioned studies designed multimedia presentations based on a theoretical understanding of how people learn from words and images driven by scientific methodology. For example, although extravagant images are visually appealing, theories of multimedia learning and cognitive load suggest elaborate images hinder learning by interfering with information processing (refer to *Theory of Multimedia Learning and Cognitive Load* for further detail) (Sweller, 1999). Extraneous cognitive load refers to abundant images and sounds that interfere with cognitive processing of important information due to distraction and split attention, leading to reduced learning.

An examination of seventy-two PowerPoint presentations delivered by engineering instructors, found that half contained backgrounds with decorative images and excessive text, which reduced comprehension and retention of key concepts (Gaudelli, Alley, Garner, Zappe, 2009). These findings suggest instructors may impede learning by ignoring the mental processing demands of certain of texts and images in multimedia design.

Theory of Multimedia Learning and Cognitive Load (Mayer Model)

The theory of multimedia learning and cognitive load proposed by Richard Mayer (herein referred to as the Mayer Model) is the foundational theoretical construct of this thesis. The Mayer Model is a research-based theory that explains how people learn from words and images. Figure 1 depicts the Mayer Model.

Figure 1.

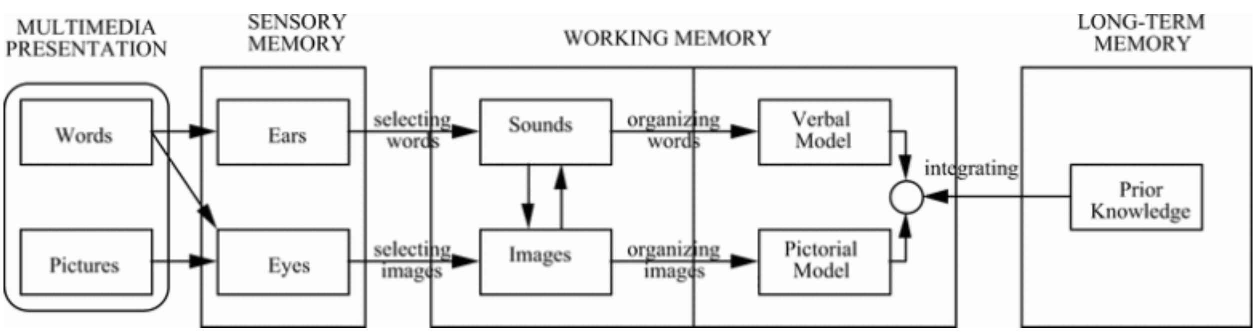


Figure 1. The Mayer Model provides a cognitive framework for multimedia learning explaining how people learn from verbal and pictorial information (Issa et al., 2011).

The Mayer Model begins by acknowledging that the human mind is limited in its capacity to attend, store, and integrate information into long-term memory (Mayer, 2009). The model makes three assumptions about how the human mind works including: 1) the dual channel assumption; 2) the limited capacity assumption; and 3) the active processing assumption.

The dual channel assumption suggests two working memory channels for processing auditory/verbal information, and visual/pictorial information. The limited capacity assumption is based on the restricted processing ability of working memory. This assumption implies the amount of verbal or visual information cognitively processed at any given time is limited. For successful learning to occur, information must be synthesized into a coherent model of knowledge and integrated into long-term memory all within the working memory store. Unlike long-term memory that can maintain limitless information, working memory can only maintain and process limited information. The active processing assumption refers to the cognitive processing involved in meaningful learning, and the ability to select, organize, and integrate incoming information into long-term memory. The way words and images are presented must not overload the limited capacity system (Mayer, 2009).

The term 'cognitive resources' will be used to describe the processing capacity of working memory for different tasks (i.e. reading, mental visualization, semantic representations of information). The number and complexity of tasks performed at any given time is restricted by limited working memory resources. To make this point more clear, take the example of talking on a hands-free cellphone while driving. Drivers engaged in hands-free cellphone conversations miss twice as many simulated traffic signals, and take longer to react to detected signals than drivers not engaged in cellphone conversations (Strayer & Johnston, 2001). Attention-based interpretations suggest hands-free cellphone use disrupts performance by diverting attention required for driving to an engaging cognitive context. Although the phone conversation is verbal and driving is visual and motor, attending to the phone conversation reduces the cognitive resources available for vigilance, motion and signal detection, and motor skill.

In addition to acknowledging the cognitive assumptions about immediate information processing, the Mayer Model outlines five cognitive processes necessary for meaningful multimedia learning.

1. The learner must select relevant *words* for verbal working memory processing
2. The learner must select relevant *images* for visual working memory processing.
3. The learner must organize the selected *words* into a verbal mental model
4. The learner must organize the select *images* into a visual mental model
5. The learner must integrate the verbal and visual models with preexisting knowledge in order to form a coherent understanding of the material.

If words or images disrupt any of these five cognitive processes, learning suffers due to an incomplete representation of information. The following section will address methods of multimedia design driven by cognitive model theory including the redundancy principle, the multimedia principle, and the image principle. Also addressed are the learning consequences of adhering to and violating these principles.

The redundancy principle assumes comprehension is hindered when learners are exposed simultaneously to identical information in multiple forms (Mayer, 2009). For example, learners' comprehension is reduced when exposed to narration and text (redundant group), rather than narration alone (non-redundant group) (Mayer, Heiser, Lonn, 2011). Similarly, comprehension suffers when learners are exposed to images, narration, and text, rather than images and narration alone (Kalyuga, Chandler, Sweller, 1999, 2000). Mayer's Model suggests redundancy reduces performance, because the visual/pictorial channel is overloaded from scanning images and text, and from comparing identical printed and spoken information. Contrary to popular belief, providing additional information with simultaneous words, images and narration does not promote learning.

In addition to the redundancy principle, the multimedia principle demonstrates enhanced learning with words and images, than with words alone. Studies examining the multimedia principle found enhanced memory for sentences with printed text and illustrations than from printed text alone (Mayer et al, 1989, 1992, 1997; Levie & Lentz, 1982). The Mayer Model suggests pairing words with images enhances the development of verbal and visual mental models, and the ability to draw connections between them. Without images, learners use excessive cognitive resources to generate visual mental models, and have greater difficulty drawing connections between verbal and visual information. Therefore, designing effective multimedia involves using non-redundant words and images rather than words alone.

In addition to the redundancy and multimedia principles, the image principle suggests enhanced learning when the speaker's image is not on screen (no-image method) rather than on screen (image-present method). However, the literature is mixed regarding the effect of the speaker's image on learning. Several studies suggest the image-present method produced superior learning compared to the no-image method (Mayer, Dow, Mayer 2003; Craig, Gholson, Driscoll, 2002), while others suggest the opposite (Moreno, Mayer, Spires, Lester, 2001). Importantly, research remains scarce regarding the image principle and human speakers, as previous studies used mainly cartoon-like speakers. Systematically varying a human speaker's image will highlight its effects on multimedia learning.

Previous literature on multimedia instruction has difficulty generalizing their findings to an academic environment due to the use of simple, short duration stimuli. Textbooks, presentations, live lectures, and computer-based lectures are more complex and significantly longer in duration. Enhancing material complexity increases cognitive processing required to manipulate information in working memory, potentially creating the need for more stringent multimedia principles.

The key hypotheses tested in this thesis are that the assumed benefit of redundant text will not enhance comprehension, and that combining non-redundant text and images will enhance learning.

Experiment 1

Experiment 1 examined effective methods of multimedia design during learning of complex material. Three computer-based lectures were created on the physiology, anatomy, evolution, and biochemical mechanisms of hunger. Lectures were eight and a half minutes in duration, and included twenty-three slides. Although lecture durations were not fully comparable to real educational settings averaging approximately fifty minutes, eight and a half minutes was a significant increase from previous research averaging approximately two minutes. Lectures contained different visual elements, such as text, images, and speaker's image. All lectures had the same audio track. Participants were randomly exposed to only one of the three lectures (although each contained the same essential information):

- **Audio only:** audio, no images
- **Redundant text:** redundant bullet-point text, speaker's image
- **Enhanced** non-redundant text (important points restated in different words), images, speaker's image

Lectures adhered to, or violated different multimedia instructional principles such as the redundancy principle, the multimedia principle, and the image principle. The primary outcome measure was comprehension of material evaluated immediately after lecture viewing. The secondary outcome measure was a subjective evaluation of perceived interest of the multimedia presentation, such as engagement level and instructor effectiveness (Webster & Ho, 1997).

Hypotheses

Based on the redundancy principle, it was hypothesized that participants exposed to audio only should outperform participants exposed to redundant text. Similarly, the enhanced lecture should outperform the redundant text lecture due to lack of verbal redundancy. According to the multimedia principle, participants exposed to the enhanced lecture should outperform participants exposed to audio only because of the use of images rather than words alone. Similarly, the enhanced lecture should outperform the redundant text lecture because of the use of images rather than verbal information alone. Although findings have been mixed regarding the speaker's image effect on learning, researchers hypothesized the speaker's image in the redundant text and enhanced lectures should not affect learning.

Regarding perceived interest measures, redundant text should lead to greater perceived interest scores than audio only (Daniel & Woody, 2010). Audio only learners desire supporting text, or images in order to increase perceived interest. The enhanced lecture should also yield greater perceived interest scores than audio only and redundant text, because images increase interest more than text and audio, regardless of image relevance (Mayer, 2002). Although participants may perceive that redundant text facilitates comprehension compared to audio only, their true comprehension may not reflect their perceived comprehension. Therefore, Experiment 1 highlights effective text and images in multimedia instruction, and also potential misperceptions about the usefulness of redundant text.

Methods

Participants

Ninety-nine undergraduate McMaster University students volunteered in the study, with thirty-three participants allocated to the three conditions. No data were discarded. Most participants were first year students, or in the 17-19 age range. A headline describing the experiment was provided using Experimetrix, an online resource for first year psychology students wishing to obtain course credit, or monetary value in return for experiment participation (see appendix for headline description). Participants could receive one course credit, or ten dollars cash for one hour of participation. The McMaster Research Ethics Board approved both experiments.

Stimuli and Apparatus

Lectures were eight and a half minutes long, and had multimedia components that violated and adhered to principles of multimedia design outlined in the introduction. Table 1 describes lecture content.

Table 1.

Audio only	**Redundant text**	**Enhanced**
• Audio only • No images **Purpose**: provides baseline measure of learning without presence of visuals	• Audio • Bullet-point verbatim on-screen text (3 bullet-points per slide) • Speaker's image (top left hand portion of computer screen, covering approximately 4-5% of display screen) o Present for 9/23 slides **Purpose**: to assess effect redundant text had on learning, along with presence of speaker's image	• Audio • Sparse text (restatements of important concepts in different words) • Speaker's image (identical to Lecture Style 2) **Purpose:** to assess effect non-redundant text and moderate amount of images, along with presence of speaker's image had on learning

Note. The above table outlines the text and image content in each lecture.

The experiment was conducted in a computer lab in McMaster University's Psychology building containing fifteen computers with headsets to avoid disturbing other participants. The number of participants at any given time was limited to twelve to avoid crowding and enable supervision. The same lab supervisor administered all trials of the experiment.

The primary outcome measure was a twenty-question comprehension quiz in multiple-choice format with four answer options (A, B, C, D). Two different question types were used in order to diversify the questions participants were exposed to; ten questions evaluated basic retention, and ten questions evaluated problem-transfer. Basic retention assesses knowledge by reinstating the context in which the original information was introduced (Halpern & Hakel, 2003). Retention does not require newly learned information to be applied to a novel scenario. Problem-transfer questions however, require newly learned information to be used in situations not previously encountered.

The secondary outcome measure was a series of six perceived interest questions. The six questions evaluated perceived interest of various multimedia traits. Answers were recorded using a 4-point Likert scale (1=absolutely agree, 2=mostly agree, 3=mostly disagree, 4=absolutely disagree). Table 2 outlines the perception measures.

Table 2.

Q1	I found the material presented in this lecture to be interesting
Q2	The lecture material has a high level of difficulty
Q3	I found that the presentation style helped me to understand the lecture material
Q4	The narrator clearly communicated the material
Q5	The overall effectiveness of the instructor was high
Q6	I found the multimedia presentation (use of images and/or words) engaging

Table 2. The above table describes verbatim the perceptive interest questions used.

A 4-point likert scale was used to avoid consistent selection of neutral middle answers, as would be the case for a 5-point or 7-point likert scale. A 4-point scale biased participants to either the positive or negative end of the spectrum, providing more insightful data.

Questions 1-3 were based on a previous study involving perception of voice pitch and instructor effectiveness (Dey, Feinberg, Kim, in prep). Questions 4-6 were developed to specifically examine the perceived interest and effectiveness of the multimedia design (see appendix for likert scale).

Limesurvey, an online survey system that creates questionnaires and collects responses, was used to collect comprehension scores, and perceived interest measures. All results were recorded on an anonymous and confidential basis by assigning individual identification numbers.

Procedure

When participants arrived, the experimenter explained that each participant would watch or listen to an eight and a half minute computer-based lecture on hunger, after which they would fill out a comprehension quiz and questionnaire. Participants were told they could withdraw at any point during the experiment. Participants were given one hour to complete the entire experiment, with at least thirty minutes to complete the quiz and questionnaire. Debriefing occurred after participants completed the quiz and questionnaire.

Design

The study was a between-groups design with lecture conditions randomly assigned. The statistical analyses examined between group comprehension, and perceived interest according to multimedia presentation condition.

Statistical Analysis

Data were analyzed using SPSS (version 17.0 windows). A one-way ANOVA examined performance between audio only, redundant text, and enhanced to determine whether comprehension differed depending on lecture condition. Independent sample t-tests compared comprehension between:

1. Audio only vs. Redundant text
2. Audio only vs. Enhanced
3. Redundant text vs. Enhanced

Mann-Whitney U tests (Mann U) were conducted on all six perceived interest questions between each lecture (three Mann U tests per question) to assess differences in perceived interest. Mann U tests were used because perceived interest questions were ordinal, and results violated assumptions of normality as indicated by the Shapiro-Wilk test ($W=0.9635$, $p=0.01$).

<u>Results</u>

Comprehension:

The three lecture conditions supported different levels of comprehension ($F(1,99)=4.28$, $p=0.02$). Participants in the audio only lecture performed similarly to those in the redundant text condition ($t(64)=-0.7$ $p=0.49$), while participants in the enhanced lecture outperformed those in the audio only lecture ($t(64)=-2.96$ $p=0.004$), and participants in the redundant text lecture ($t(64)=-2.44$, $p=0.02$). Figure 2 depicts these results.

Figure 2.

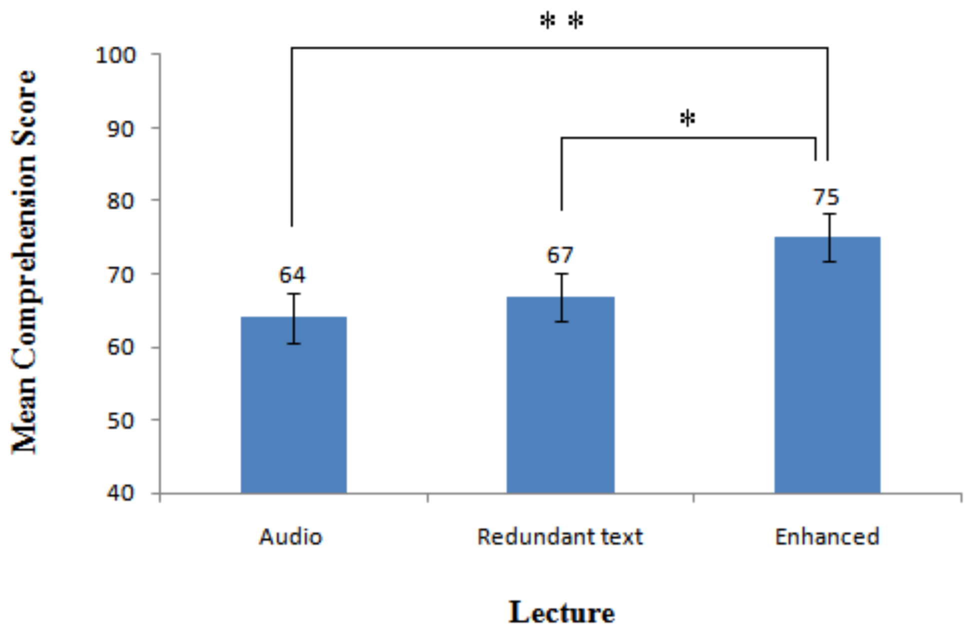


Figure 2. There was no difference in performance between audio only and redundant text, but a significant difference in performance between enhanced and audio only, along with enhanced and redundant text. *<0.05, **<0.01

Perceived Interest: Mann-Whitney U comparisons

Three Mann U analyses were conducted for each perceived interest question between (1) audio only vs. the redundant text, between (2) audio only vs. enhanced, and (3) redundant text vs. enhanced. Figure 3 depicts the perceived interest scores across all three conditions, along with results of the Mann U analyses graphically.

Figure 3.

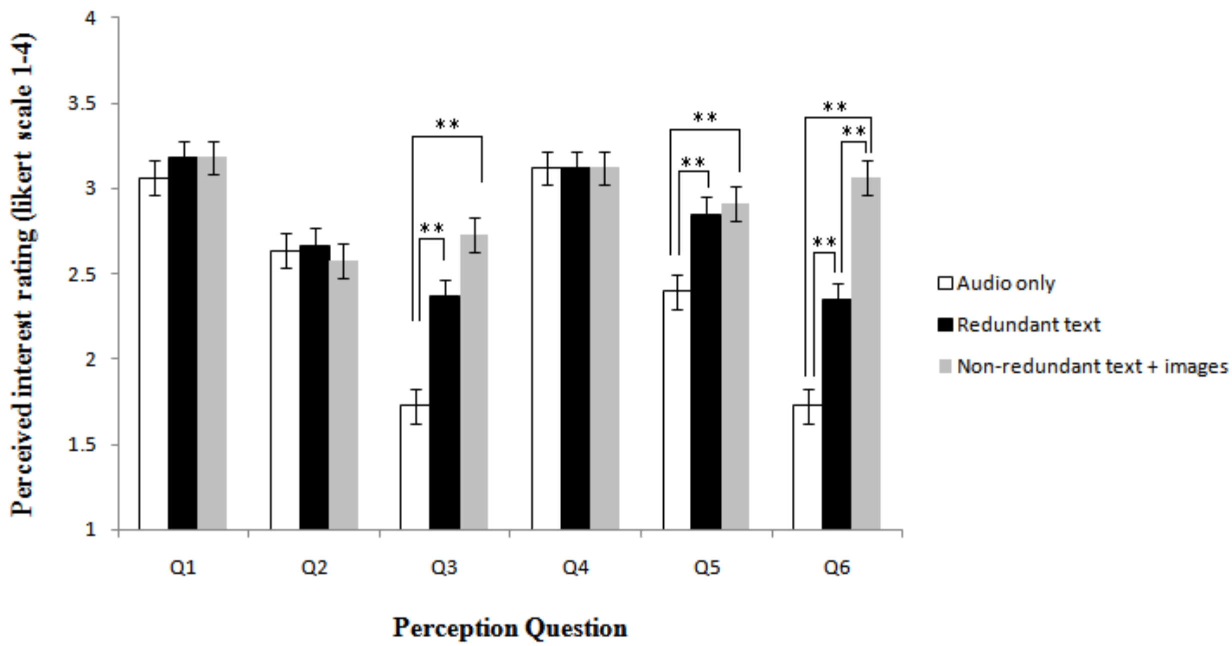


Figure 3. This graph shows the significant differences in perceived interest ratings between specific lectures for question 3, question 4, and question 6. Questions 1, 2, and 4 yielded no significant differences in perceived interest ratings between lectures. *<0.05, **<0.01

Interestingly, regardless of multimedia design, all lectures perceived the material as equally interesting and difficult. Narrator clarity was also perceived as similar across lectures (p>0.05). Participants exposed to redundant text perceived that the presentation style promoted greater understanding compared to audio only. Also, participants exposed to the enhanced lecture perceived the presentation promoted greater understanding compared to audio only, but not compared to redundant text. Furthermore, participants exposed to redundant text perceived instructor effectiveness as greater than participants exposed to audio only. Participants exposed to the enhanced lecture perceived instructor effectiveness as greater compared to audio only, but not compared to redundant text. In addition, the enhanced lecture promoted greatest engagement scores, while audio only received lowest engagement scores.

Discussion: Experiment 1

Experiment 1 found learning was enhanced when lectures contained non-redundant text and images, compared to when lectures contained redundant text, or audio only. Although learning did not differ between redundant text and audio only, the redundant text presentation style was perceived as promoting better understanding, instructor effectiveness, and learner engagement. Interestingly, these enhanced perceptions were not matched by improved performance, as there was no difference in comprehension between redundant text and audio only lectures. The following sections will address the effectiveness of multimedia principles in a complex learning environment, and will also discuss potential reasons for paradoxical perceptions of comprehension, instructor effectiveness, and engagement level.

The redundancy principle, which assumes learning is hindered with narration and text rather than narration alone, was supported in a complex learning environment (Mayer, 2009). Although the redundancy principle argues audio only should outperform redundant text, similar comprehension performance refutes the common belief that redundant text is a beneficial visual aid. In addition, multimedia presentations containing non-redundant text and images promoted learning to a higher degree than redundant text only. Future work investigating cognitive explanations for decreased learning with redundant text will be discussed later. Overall, these results suggest multimedia instruction should be designed using images, and non-redundant text in order to adhere to the redundancy principle and promote learning.

The multimedia principle, which assumes learning is improved with words and images, rather than with words alone, was also supported. The enhanced lecture produced superior comprehension compared to the audio only and redundant text lectures. These results support the contention that images aid in forming visual mental models during learning. Narration or text alone burdens the pictorial working memory channel, because visual mental representations of information must be generated without external aid. Learner suffers because greater cognitive resources are allocated to forming visual mental models, and fewer resources remain to comprehend material.

Regarding the image principle, the presence of the speaker's image did not hinder learning. The speaker's image in the redundant text lecture did not affect comprehension compared to the audio only condition, which did not contain the speaker's image. Although the enhanced lecture contained the speaker's image, and learning was greater compared to audio only, this effect was most likely due to the images and non-redundant text. This assumption is justified because if the speaker's image benefited comprehension, then the redundant text lecture containing the speaker's image, should have outperformed the audio only lecture.

Overall, this study demonstrated using non-redundant text, and a moderate number of images, promoted learning in multimedia presentations. In addition, regardless of whether the speaker's image was present or absent, learning did not suffer, and can therefore be used at the discretion of the multimedia instruction coordinator. Further research must examine the speaker's image effect during longer multimedia presentations in order to gain additional reliability in realistic educational settings.

Perception measures demonstrated several interesting findings. Participants exposed to redundant text perceived their understanding was facilitated by the presentation style to a greater extent than participants exposed to audio only. Interestingly, redundant text participants were misled in their perception of presentation style effectiveness, because they did not outperform audio only participants. Using redundant text during multimedia instruction instilled a false belief that supporting text aided understanding. The misconception that redundant text intuitively facilitates understanding may prevent learners from engaging optimally with information. These results support the claim that learners are poor evaluators of comprehension, because they do not accurately perceive the negative effects of redundant text (Kruger & Dunning, 1999). Additionally, the enhanced lecture did not perceive the presentation style promoted greater understanding compared to the redundant text lecture. Not only were learners unaware that redundant text did not promote learning, they were unaware that non-redundant text and images facilitated learning. Instructors and learners must be educated on the beneficial and detrimental uses of text and images in multimedia presentations in order to maximize both educational experiences.

Additionally, redundant text participants perceived instructor effectiveness as greater than audio only participants, although comprehension did not differ between lectures. This further highlights learners' beliefs that redundant text promotes multimedia effectiveness. In contrast, using images and non-redundant text compared to audio only generated accurate perceptions of instructor effectiveness reflected by superior comprehension in the enhanced lecture.

Redundant text also had greater perceived engagement than audio only, although comprehension did not differ between lectures. Importantly, engagement levels should reflect increased attention and information processing. Although learners were more engaged in the redundant text lecture, their similar performance to audio only suggests their engagement did not predict learning. In contrast, the enhanced lecture had greater perceived engagement than audio only, and redundant text. Since the enhanced lecture outperformed audio only and redundant text, multimedia presentations with images and non-redundant text instilled perceptions of engagement that accurately predicted learning. Therefore, learners mistakenly perceived redundant text facilitated understanding, instructor effectiveness, and engagement compared to audio only. Furthermore, participants often did not recognize the benefits of the enhanced lecture compared to the redundant text lecture.

There were no differences regarding how interesting lectures were perceived. Learners did not base their interest in lecture material on extraneous multimedia factors. Although audio only and redundant text were less engaging overall, perceived interest of lecture material was unaffected. Also, perceived difficulty of lecture material did not differ among lectures although audio only and redundant text performed worse than the enhanced lecture. Perhaps images reduced the difficulty of forming visual mental models and improved learning, but on a subconscious level. This further supports the contention that learners do not accurately judge comprehension, because they do not recognize the benefits of images and non-redundant text.

In addition, there were no differences in perceived narrator clarity across lectures. However, superior comprehension performance in the enhanced lecture indicates the narrator's ability to effectively communicate information was worse in the audio only and redundant text lectures. Again, this highlights how learners did not recognize the positive and negative aspects of a multimedia presentation.

Overall, perceived interest results suggest it is important to educate instructors and learners on the efficient use of text and images in multimedia design. This allows instructors and learners to overcome the intuitive assumption that redundant text aids learning, and realize the benefits of images and non-redundant text.

Limitations of Experiment 1

One limitation was variable manipulation. Some lecture comparisons had two or more variable manipulations. For example, one lecture contained audio only, but the other lecture contained redundant text and the speaker's image. It would be difficult to determine if comprehension differences resulted from the effects of redundant text, or the speaker's image. Experiment 2 was designed to address the limitation of variable manipulation. A 2x2 crossed-factorial design was implemented with only two variable manipulations: text (redundant vs. non-redundant) and image (present vs. absent). The speaker's image was removed from Experiment 2, because it did not affect learning in Experiment 1. Two important goals of Experiment 2 were to rigidly control variables and replicate the suboptimal effect of redundant text in Experiment 1, and to gain further insight into valuable combinations of text and images in multimedia instruction.

Experiment 2

Experiment 2 investigated effective combinations of text (redundant vs. non-redundant) and image (present vs. absent). Participants were randomly exposed to one of four computer-based lectures identical in content and duration to Experiment 1.

1. **Complex** (redundant text, images)
2. **Redundant text** (redundant text only)
3. **Enhanced** (non-redundant text, images)
4. **Sparse text** (non-redundant text only)

Pictorial representations of lectures are provided in section "*Methods: Stimuli and Apparatus"*. The primary outcome measure of comprehension performance was identical to Experiment 1. Two secondary outcome measures were used including the same perceived interest measures as Experiment 1, and questions assessing depth of information processing. Examining depth of information processing was used to provide insight into whether certain text and image combinations promoted shallow information processing, consequently reducing performance (see Methods). The goals of Experiment 2 included replicating the suboptimal effect of redundant text, investigating text and image combinations that promote deep and meaningful information processing, and further understanding perceived interest of multimedia presentations.

Hypotheses

It was hypothesized that the complex lecture, the redundant text lecture, and the sparse text lecture would reduce learning compared to the enhanced lecture. The Mayer

Model and Experiment 1 results suggest that redundant text should overload the verbal processing stream and hinder learning. Also, the absence of images in the sparse text lecture should increase difficulty in forming visual mental representations of information consequently reduce learning. Therefore, the enhanced lecture should produce the greatest learning, while other lectures should produce similar learning to one another.

Regarding perceived interest measures, learners in the redundant text lecture were hypothesized to have higher perceived interest than the sparse text lecture, due to increased visual stimulation. However, Experiment 1 demonstrated comprehension might not improve even with greater interest in redundant text. Highest perceived interest was hypothesized to result from exposure to the enhanced lecture, along with the complex lecture due to the use of images.

With respect to depth of information processing, the redundant text lecture and the complex lecture were hypothesized to produce shallowest levels of processing. The rationale for this hypothesize was based on the notion that learners resort to passive learning when verbatim text is present, and do not effectively engage with information to promote deep processing. The sparse text lecture was hypothesized to produce shallow levels of processing similar to lectures containing redundant text, because generating mental representations of pictorial information disrupts deep processing of information. The enhanced lecture was hypothesized to yield deepest processing, because verbal working memory would not be overloaded, and images would aid visual mental model generation.

Methods

Participants

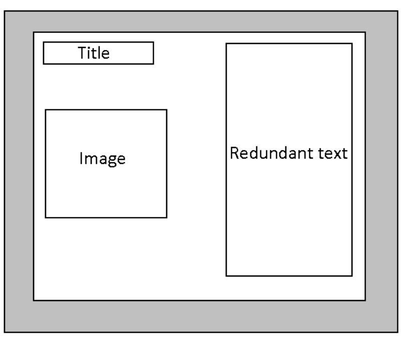
Eighty-four undergraduate McMaster University students volunteered in the study, with twenty-one participants allocated to each of the four lectures. No data were discarded. Most participants were first year students, or in the 17-19 age range. A headline describing the experiment was provided using Experimetrix (see Experiment 1 Methods) Participants were compensated with one course credit.

Stimuli and Apparatus

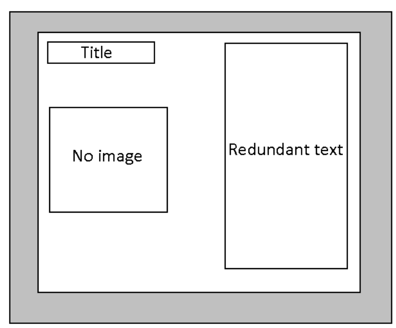
Lecture information and duration was identical to Experiment 1. Figure 4 illustrates lecture layout.

Figure 4.

1. Complex



2. Redundant text



3. Enhanced

4. Sparse text

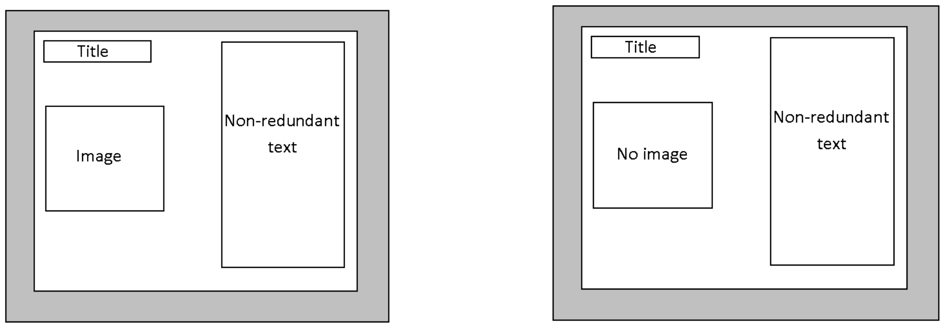


Figure 4. The figure depicts the layout of each lecture. Three regions of interest (ROIs) (Title, Text, Image) were created with all four lectures containing the same "Title" ROI, while the content of the "Image" ROI, and the "Text" ROI varied.

Table 3 describes lecture content and reflects the 2x2 factorial nature of the design. The title region of interest (ROI) was identical across lectures, with a new title appearing at the change of each slide (total of 18 slides). Images were also identical when present.

Table 3.

<table>
<tr><td rowspan="4">Image</td><td colspan="3">Text</td></tr>
<tr><td></td><td>Redundant</td><td>Non-redundant</td></tr>
<tr><td>Present</td><td><u>Complex:</u>
• new title reflecting content of each slide
• verbatim text
• images
• purpose: to assess learning when redundnant text and images are used together</td><td><u>Enhanced:</u>
• new title reflecting content of each slide
• sparse text (restatements of important concepts in different words)
• images
• purpose: to assess whether the combination of sparse text and images produces optimal learning</td></tr>
<tr><td>Absent</td><td><u>Redundant text:</u>
• new title reflecting content of each slide
• verbatim text
• purpose: to replicate findings from Experiment 1, which found redundant text hinders learning</td><td><u>Sparse:</u>
• new title reflecting content of each slide
• sparse text (restatements of important concepts in different words)
• purpose: to assess whether absence of images hinders learning, even though text is non-redundant</td></tr>
</table>

Note. The above table describes the text and image content in each lecture.

The primary outcome measure was identical to Experiment 1 (see Experiment 1 Methods: Stimuli and Apparatus). The secondary outcome measure of perceived interest was identical to Experiment 1 with one question added. Table 4 outlines perceived interest measures with the additional question in bold. The additional question was used to directly assess perceived understanding of material

Table 4.

Q1	I found the material presented in this lecture to be interesting
Q2	The lecture material has a high level of difficulty
Q3	I found that the presentation style helped me to understand the lecture material
Q4	The narrator clearly communicated the material
Q5	The overall effectiveness of the instructor was high
Q6	I found the multimedia presentation (use of images and/or words) engaging
Q7	**I found that I had a good understanding of the material overall**

Note. The above table depicts the perceived interest questions in Experiment 2, with the added question assessing lecture understanding in bold.

In addition to perceived interest, ten questions assessed whether participants processed information at a shallow or deep level. Participants were required to identify the exact sentence that appeared in the lecture out of three options. The first option was the exact sentence (shallow level processing). The second option was a lecture concept phrased in a different way (deep level processing). The third option was a completely novel sentence not presented (control). The order of shallow, deep, and novel statements was randomized across the ten questions. Participants exposed to redundant text were hypothesized to be superior at extracting exact statements, but perform worse on comprehension. In contrast, enhanced lecture participants would be more likely to select the deep processing option.

Procedure

The experimental procedure was identical to Experiment 1 (see Experiment 1 Methods: Procedure), with the addition that participants completed the levels of processing questions following the perceived interest questionnaire (see Experiment 1 Methods: Procedure).

Design

The design was a 2x2 between-groups factorial design.

Statistical Analysis

Data were analyzed using R (open source statistical software), and SPSS (version 17.0 windows). Two-by-two factorial ANOVAs examined main effects of text and image, along with text-by-image interactions for overall comprehension, recall comprehension, and applied comprehension. There was a significant text-by-image interaction for recall comprehension only. All further analyses including simple main effects, and linear contrasts were conducted on recall performance only.

Non-parametric Mann-Whtiney U tests were conducted on perceived interest questions because they were ordinal, and violated assumptions of normality indicated by the Shapiro-Wilk test ($W=0.96$, $p=0.01$). Three Mann U tests per question were conducted between lectures differing in comprehension. Comparisons were between: 1) Complex vs. Redundant text, 2) Redundant text vs. Enhanced, 3) Redundant text vs. Sparse text.

Depth of information processing was analyzed using independent sample t-tests on shallow, deep, and novel categories of processing between lectures with significant differences in comprehension. Therefore, three t-tests were conducted for each depth of processing category between 1) Complex vs. Redundant text, 2) Redundant text vs. Enhanced, 3) Redundant text vs. Sparse text.

Results: *Primary Outcome Measure*

Comprehension: Factorial ANOVA on Overall Performance

A 2x2 factorial ANOVA with factor 1) Text (level 1: redundant, level 2: non-redundant), and factor 2) Image (level 1: present, level 2: absent) was conducted on overall comprehension performance. There was a marginal main effect of text ($F(1,80)=2.62$, $p=0.11$), a marginal main effect of image ($F(1,80) = 3.43$, $p=0.07$), and marginal interaction ($F(1,80) = 2.51$, $p=0.12$). Without a significant interaction between levels of text and levels of image, simple main effects and linear contrasts were not examined. Figure 5 depicts the 2x2 factorial result.

Figure 5.

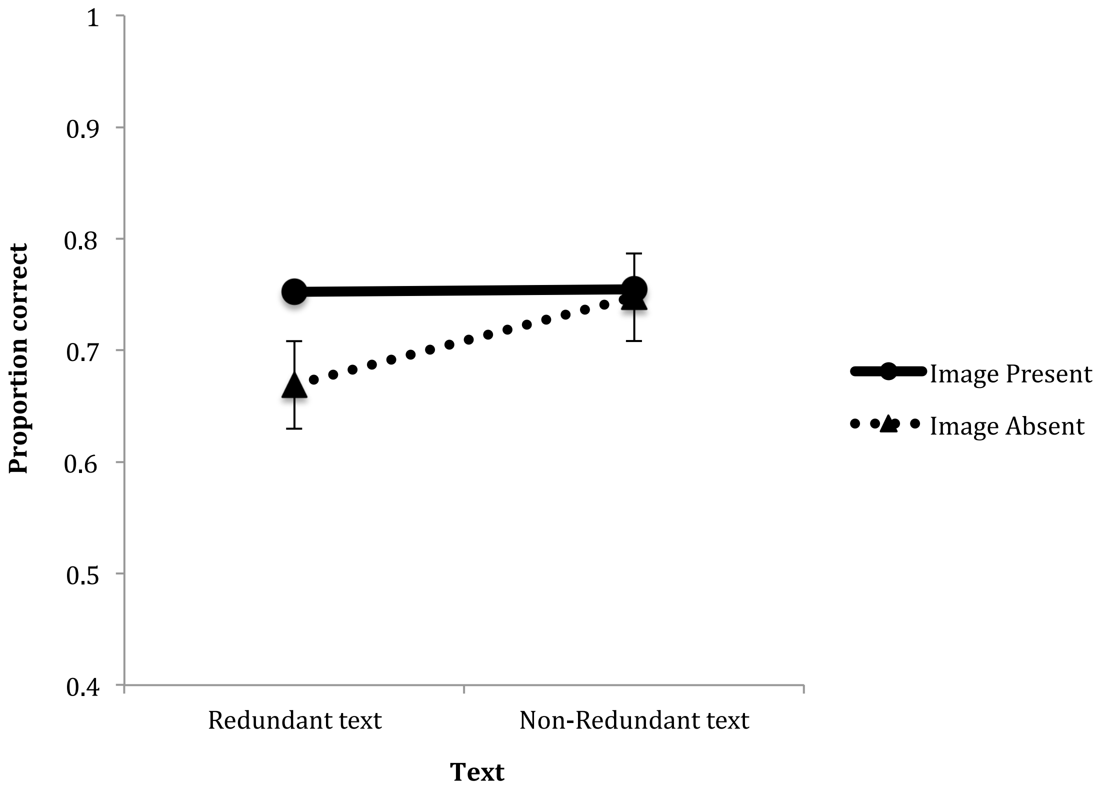


Figure 5. The above graph shows no main effects of text or image, and no interaction for overall comprehension.

Comprehension: Factorial ANOVA on Applied Performance

A 2x2 factorial ANOVA with the same factors and levels was conducted on applied performance. There was no main effect of text ($F(1,80) = 0.78$, $p=0.38$), no main effect of image ($F(1,80) = 2.45$, $p=0.12$, and no interaction ($F(1,80) = 0.38$, $p=0.54$). Without an interaction, simple main effects and linear contrasts were not examined. Figure 6 depicts the 2x2 factorial result.

Figure 6.

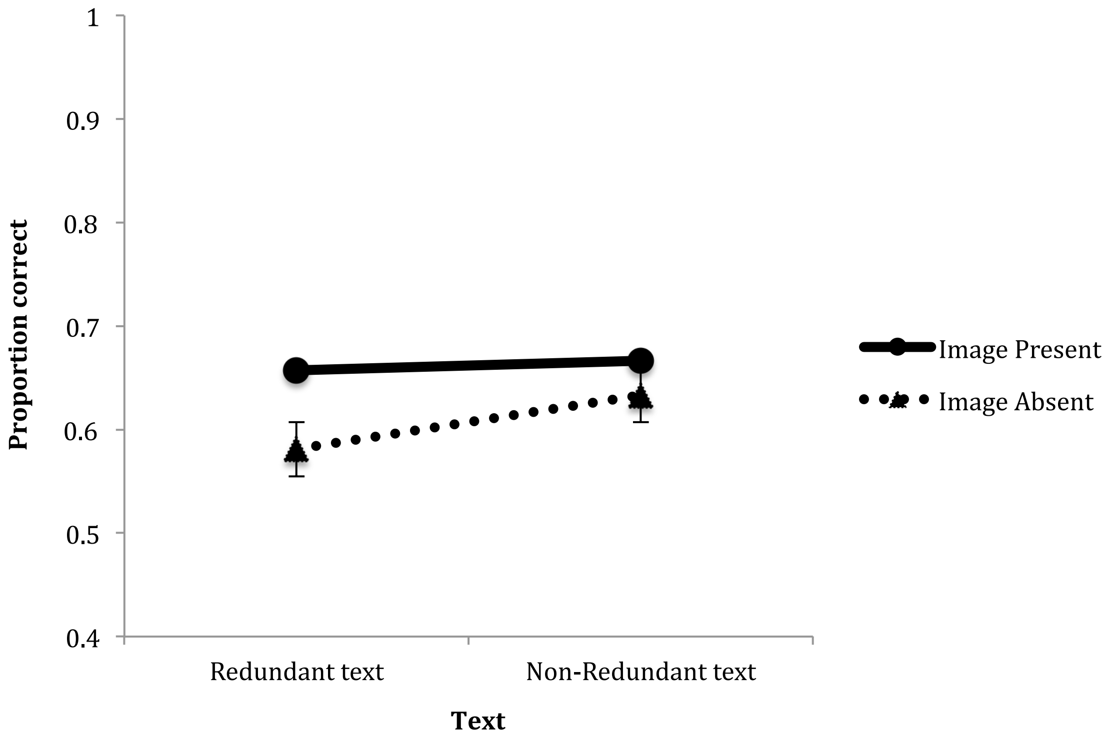


Figure 6. The above graph shows no main effects of text or image, and no interaction for applied comprehension.

Comprehension: Factorial ANOVA on Recall Performance

A 2x2 factorial ANOVA with the same factors and levels was conducted on recall performance. There was a marginal main effect of text (F(1,80) = 3.37, p=0.07), no main effect of image (F(1,80) = 1.72, p=0.19), and a significant text-by-image interaction (F(1,80) = 4.05, p=0.05). Figure 7 depicts this result. Simple main effects of image at each level of text (redundant, non-redundant), and simple main effects of text at each level of image (present, absent) were conducted. Linear contrasts between specific lectures were conducted on significant simple main effects and a priori hypotheses.

Figure 7.

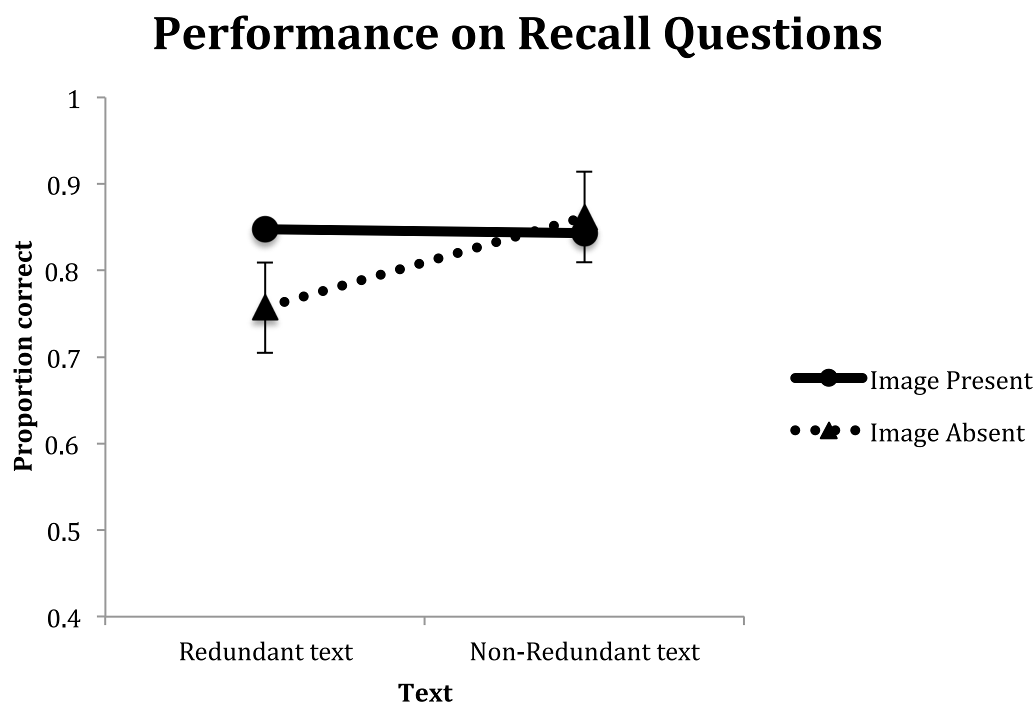


Figure 7. The above graph shows no main effect of text, no main effect of image, and a significant text-by-image interaction.

Comprehension: Simple main effects and linear contrasts

There was a significant simple main effect of redundant text at each level of image (present, absent) (F(1,40) = 5.52, p=0.02). Linear contrasts found that the complex lecture produced superior learning compared to the redundant text lecture (F(1,40)=5.52, p=0.02). There was no simple main effect of image present at levels of text (F(1,40) = 0.02, p=0.9), therefore the complex and enhanced lectures did not differ in comprehension.

There was also a significant simple main effect of image absent at levels of text (redundant, non-redundant) (F(1,40) = 7.41, p=0.01). Linear contrasts found that the sparse text lecture produced superior learning compared to the redundant text lecture ($F(1,40)=7.41$, $p=0.01$).

Furthermore, linear contrasts found that the enhanced lecture produced superior learning compared to the redundant text lecture ($F(1,40)=4.96$, $p=0.03$), and that there was no difference in learning between the enhanced and sparse text lectures ($F(1,40)=0.25$, $p=0.62$).

Results: *Secondary Outcome Measures*

Perceived Interest

Three Mann U analyses were conducted for perceived interest questions between lectures with significant linear contrasts. All lectures were not compared to reduce the number of pairwise comparisons and Type I error. Mann U comparisons were between 1) Complex vs. Redundant text, 2) Redundant text vs. Enhanced, 3) Redundant text vs. Sparse text. The enhanced lecture had greater perceived interest ratings compared to the redundant text lecture on all questions excluding narrator clarity. Although the sparse text lecture produced greater comprehension compared to redundant text, perceived interest ratings were identical for all questions. Similarly, the complex lecture produced superior learning compared to redundant text, but perceived interest ratings were identical for most questions. Figure 8 depicts the results.

Figure 8.

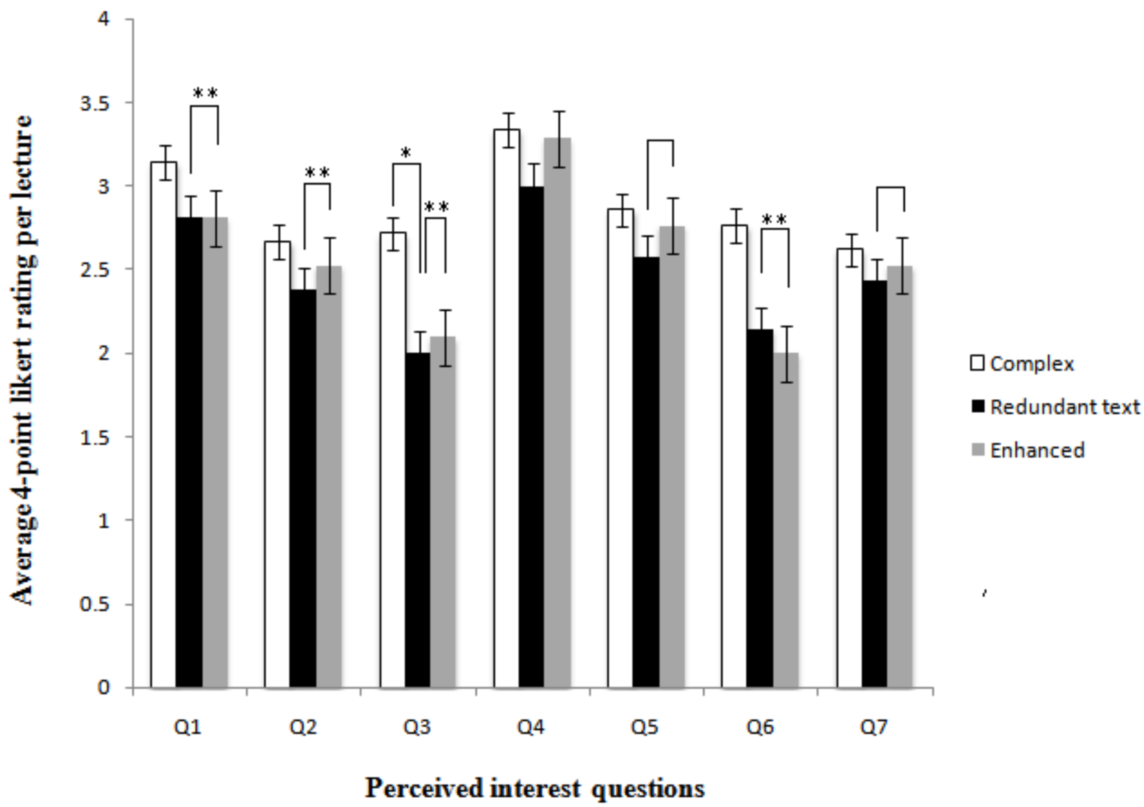


Figure 8. This graph shows perceived interest results. The asterisks indicate lectures differing in comprehension.

Depth of Information Processing

There was no difference in depth of information processing between lectures compared although there were clearly differences in comprehension performance. The discussion section will address potential reasons for these findings. Table 5 shows the results of t-tests conducted for each category of information processing (shallow, deep, novel) between 1) Complex vs. Redundant text, 2) Redundant text vs. Enhanced, 3) Redundant text vs. Sparse text.

Table 5.

	Complex vs. Redundant text	Redundant text vs. Enhanced	Redundant text vs. Sparse text
Shallow	F(1,40)=0.04, p=0.84	F(1,40)=0.74, p=0.39	F(1,40)=0.46, p=0.5
Deep	F(1,40)=0.28, p=0.60	F(1,40)=0.59, p=0.45	F(1,40)=0.04, p=0.85
Novel	F(1,40)=0.15, p=0.7	F(1,40)=0.02, p=0.9	F(1,40)=0.49, p=0.49

Note. This table shows there was no difference in depth of information processing between lectures compared.

Discussion: Experiment 2

Experiment 1 found redundant text produced poorest learning, and generated lowest perceived interest ratings. However, learning significantly improved when redundant text was paired with images. The complex lecture may have promoted greater attention to images than redundant text avoiding overload of verbal working memory. Additionally, images may have promoted similar attentional processing of text and images between the complex and enhanced lectures resulting in similar performance. The section *Future Directions* addresses future research investigating reasons for similar learning between complex and enhanced lectures. Despite learning similarities, the enhanced lecture received significantly higher perceived interest ratings on most questions compared to the complex lecture. Importantly, facilitating long-term learning requires texts and visuals that promote simultaneous comprehension and interest.

Contrary to predictions, learning was also enhanced with sparse text relative to redundant text only. Absence of images did not hinder pictorial mental model formation. However, the sparse text lecture received lower perceived interest ratings than lectures with images. Low interest may reduce long-term learning, which suggests multimedia instruction should promote not only learning but high interest.

There are several additional perceived interest findings. Although the sparse text lecture produced greater learning than the redundant text lecture, they did not differ on perceived interest ratings. Learners falsely perceived sparse text did not aid learning. However, learners accurately assessed the benefits of the enhanced lecture compared to redundant text with greater perception ratings on all questions, excluding narrator clarity.

Overall, although complex, enhanced, and sparse lectures performed similarly, only the enhanced lecture increased perceived interest ratings compared to redundant text. If the goal of multimedia instruction is to promote learning and interest, the enhanced lecture is a valuable template.

There were no differences between lectures regarding depth of information processing. Although examining levels of processing highlights important learning practices, the questionnaire may not have been sufficiently sensitive to parse out differences between lectures. Tools evaluating depth of information processing need to be refined in order to observe any effects.

Limitations: Experiment 2

An important limitation to Experiment 2 was the ineffectively designed depth of information processing questions. The options in each question (shallow, deep, novel) were not independent categories, and could not tease apart the occurrence of shallow or deep processing. The exact statement (indicative of shallow processing) also contained conceptual information. Learners could have recognized the exact statement, but also the underlying concept demonstrating deep processing. To sensitize the evaluative tool, researchers must create exact statements lacking conceptual importance, and create deep statements containing conceptual importance without direct reference from lectures. Understanding depth of processing limitations from text and images further improves multimedia design.

General Discussion

Comparisons between Experiment 1 and Experiment 2

One similarity between experiments was participants did not perceive the learning benefits of non-redundant text compared to redundant text. This further supports the common belief that more text is always beneficial to learning. These findings should encourage instructors to facilitate learning through active mental processing, which redundant text hinders. In contrast to Experiment 1, enhanced lecture participants accurately assessed the benefits of pairing non-redundant text and images compared to redundant text only with greater perceived interest ratings. Interestingly, redundant text in Experiment 2 was perceived as significantly worse than redundant text in Experiment 1. These discrepant results may be due to differences in lecture design, with redundant text confined to a smaller region in Experiment 2. The most important similarity between experiments was the replication that redundant text alone negatively impacted learning, while often promoting positive perceptions.

Limitations of the Mayer Model

Although this thesis used the Mayer Model as the main theoretical framework for experimental design and interpretation, the model has several limitations. One important limitation is that self-paced learners who take more time to understand multimedia material, even when exposed to on-screen text and images, perform similarly to those exposed to narration and images, reversing split-attention effects (Harskamp, Mayer, Suhre, 2007). The split-attention effect was only observed when learning time was restricted. Therefore, Mayer's Model may only apply to learning circumstances where control is restricted, and where leaners have a single exposure to material. Cognitive load may be minimized with repeated presentations and longer learning periods by increasing prior knowledge and facilitating memory for material.

Future work should investigate long-term effects of text and images in multimedia instruction providing a more realistic model of academic learning.

In addition, several criticisms have surfaced regarding the Mayer Model's assumption that on-screen texts demand the same working memory subsystem as pictures (visual/pictorial working memory channel) (Rummer, Schweppe, Furstenberg, Seufert, Brunken, 2010). Critics have suggested visual and auditory texts are processed within a single working memory store: the phonological loop. Research has demonstrated memory for simple written sentences was similarly retained for images held within working memory regardless of complexity (Rummer et al., 2010). Recall of written sentences should have decreased as images increased in complexity due to reduced visual/pictorial working memory resources for remembering verbal information. In opposition to the Mayer Model, these findings suggest auditory and visual text processing only involves different modality specific sensory systems, but do not demand different working memory components. With these criticisms in mind, the Mayer Model provides an important avenue for a priori experimental design, and facilitates important research in multimedia instruction. However, future work should address whether the Mayer Model should be modified to incorporate how texts and images impact long-term learning, and affirm whether visual and auditory information is processed in separate working memory streams.

Implications

Multimedia instruction and learning research has practical and theoretical implications. Practically, multimedia is increasing in prevalence in educational settings, and is often used is ways not beneficial to learning. This thesis demonstrated redundant text hindered learning, yet was often perceived as an effective aid to comprehension. Also, the learning benefit of images was often overlooked. This research promotes learning by providing educators with pedagogically sound methods of using text and images in multimedia instruction.

Theoretically, multimedia research can promote questions about complex information processing and storage. Examining why certain text and images affect learning highlights online mental learning mechanisms, and emphasizes restrictions of working memory during information acquisition. Investigating not only *which* text and images affect learning, but also *why* they affect learning drives new theory and research in memory and learning.

Future Directions

Future research will use eye-tracking technology to measure overt visual attention during multimedia presentations with different text and images. Eye-tracking localizes cognitive processing to specific aspects of the visual scene, providing direct attentional evidence of text and image effects during learning (Kuhn & Findlay, 2009). Eye-tracking can examine whether redundant text consumes abundant visual attention, and how this affects learning through comprehension performance. Current research reinforces the negative impact of redundant text on learning, but future work should address the cognitive explanations for *why* redundant text hinders learning. Questions such as, "Does redundant text promote reading-like behaviour, which negatively impacts learning?" and "Does redundant text prohibit learners from deep processing of information"? will provide behavioural and cognitive evidence for effective multimedia design.

In addition, eye-tracking can examine why redundant text does not hamper learning when paired with images. Perhaps learning is unaffected because visual attention is directed to images even in the presence of redundant text reducing verbal working memory load. Also, examining transitions between text and images will highlight integration of information since assimilation of pictorial and verbal representations is enhanced as transitions increase. Furthermore, future work should address how multimedia templates affect long-term learning since assessments of comprehension occur days or weeks after viewing multimedia presentations in realistic educational settings.

Additionally, future research should focus on a within-subjects experiment, exposing learners to two different multimedia presentations (i.e. redundant text and sparse text), and having them rate perceived interest of both presentations. A within-subjects design will further highlight if learners can accurately perceive the benefits of multimedia presentations that promote learning, or if their perceptions fail to match their performance.

In conclusion, these experiments provide important evidence for the valuable and detrimental designs of multimedia instruction, and promote avenues of important future research in cognition and learning. Institutions and instructors must acknowledge cognitive and learning limitations, and design multimedia presentations with text and images that promote learning and interest.

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Appendix

Comprehension Questions

1. Cannon and Washburn (1992) proposed an interesting answer to why people feel hungry. What answer did they purpose?

    a. You feel hungry when the walls of your intestine rub against each other
    b. You feel hungry when the glucose in your stomach causes a sensation of emptiness
    c. You feel hungry when the walls of your stomach rub against each other

d. You feel hungry when your small intestine contracts, and sends digestive enzymes up to your stomach

2. Dr. Burn is testing the role of the liver in monitoring glucose levels to control feeding behaviour. Although he injects two similar dogs with a sufficient load of glucose, one stops eating while the other continues to eat. Solve what is most likely to have happened?

a. The dog that continues to eat is extremely hungry and the glucose had no impact
b. The dog that continues to eat is low on glycogen levels
c. The dog that continues to eat had the glucose injected into a vein that <u>does not</u> reach the liver
d. The dog that continues to eat had the glucose injected into a vein that <u>does</u> reach the liver

3. In 1944, Inglefinger studied cancer patients with their stomachs surgically removed. Describe what his study concluded about feelings of hunger?

a. You need a stomach in order to feel hungry
b. You do not need a stomach in order to feel hungry
c. Individuals without stomachs do not report feelings of hunger
d. You need only part of your stomach to feel hungry

4. You have discovered an animal that does not seem to employ glycogen stores (or an equivalent). Applying your knowledge about glycogen stores, you might expect this animal to:

a. Eat frequently and have highly variable glucose levels
b. Eat frequently and have consistently low glucose levels
c. Eat infrequently and have highly variable glucose levels
d. Eat infrequently and have consistently low glucose levels

5. Physiological evidence indicates that part of the _____ controls the cessation of feeding. It appears to do so by ______.

a. hypothalamus…monitoring stomach distension
b. thalamus…monitoring the rate of glucose use
c. hypothalamus…monitoring the rate of glucose use
d. limbic system…monitoring the rate of glucose use

6. Dr. Smith discovers one of his patients (Mike) has been gaining weight. Upon closer inspection, Dr. Smith discovers Mike's leptin levels are abnormally low. What role does leptin play in long-term weight regulation?

a. When fat tissue increases, leptin production is halted, and daily food consumption is lowered
b. When an individual feels hungry, leptin levels rise, and signal the body to consume food
c. When an individual feels hungry, leptin levels rise, and signal the body to reduce food consumption
d. When fat tissue increases, leptin levels rise, and is involved in reducing daily food consumption.

7. As glucose levels drop:

a. You start feeling full
b. Remaining glucose is quickly converted into glycogen
c. Glycogen is broken down into glucose
d. Fat is stored

8. Peter's liver is correctly identifying glucose levels in his blood. Frank's liver is incorrectly identifying glucose levels in his blood. What would be the difference between Peter and Frank's liver activity?

a. Peter's but not Frank's liver would be breaking down glycogen into glucose when glucose levels are low
b. Frank's but not Peter's liver would be breaking down glycogen into glucose when glucose levels are low
c. Peter's but not Frank's liver would be converting glucose into glycogen when glycogen levels are low
d. Frank's but not Peter's liver would be converting glucose into adipose tissue when glycogen levels are low

9. A pharmaceutical company is trying to create a drug that will help obese clients lose weight. Taking advantage of what you have learned thus far, which of the following approaches would be best?

a. Create a drug that mimics the function of Leptin

b. Create a drug that stimulates the liver to break down glycogen to glucose
c. Create a drug that blocks the receptors of NPY
d. Create a drug that stimulates the overproduction of adipose tissues

10. Dr. Smith discovers the presence of a hormone in the small intestine, which he hypothesizes, causes feelings of fullness, and reduces eating. Which following observation (if found) would argue against his hypothesis?

a. When this hormone was injected into subjects, it resulted in feelings of nausea. Therefore, perhaps nausea, and not a feeling of fullness, reduced food consumption
b. When this hormone was injected into subjects, it caused stomach constriction and intense gastrointestinal pain. Therefore, perhaps pain, and not a feeling of fullness, reduced food consumption.
c. When this hormone was injected into subjects, it caused stomach the esophagus to constrict, consequently preventing food consumption. Therefore, perhaps esophagus constriction, and not a feeling of fullness, reduced food consumption.
d. When this hormone was injected into subjects, feelings of fatigue resulted. Therefore, perhaps fatigue, and not feelings of fullness, reduced food consumption.

11. Which nutrient signals the need to replenish one's food intake?

a. glucose
b. fructose
c. adipose tissue
d. glycogen

12. In a transporter malfunction, John's stomach was accidently removed. What effect will it have on his eating habits?

a. John will eat more
b. John will eat slighty less
c. John will now experience highly variable levels of hunger
d. No effect

13. What hormone, produced in the small intestine, is hypothesized to be related to feelings of fullness?

a. PPY
b. CCK
c. Leptin
d. Glucose

14. According to the lecture, which part of the brain is the most important in the regulation of hunger and satiety?

a. olfactory bulb
b. prefrontal cortex
c. hippocampus
d. hypothalamus

15. According to the lecture, "our lives seem dominated by the consumption of food". What was the evolutionary rationale behind this statement?

a. In the past, humans had to expend more effort in order to find food than is typical for modern industrial societies today.
b. In the past, humans had to expend minimal effort in order to find than is typical for modern industrial societies today.
c. In the past and in present industrial societies, humans expend a great deal of energy seeking out scarcely available food.
d. In the past and in present industrial societies, humans expend less energy seeking out scarcely available food.

16. Stimulation of the ventromedial nucleus of the hypothalamus in rats might be expected to cause:

a. an increase in food intake and weight gain
b. a sharp decrease in food intake (or its complete cessation) and weight loss
c. a transition from waking to sleep, if the stimulation is of high frequency
d. permanent wakefulness

17. John acquires a head injury during a car accident and over the subsequent weeks he gains over 80 pounds. What may have been the cause for his excessive weight gain?

a. Overproduction of CCK in the brain
b. Lateral hypothalamus damage
c. Ventromedial hypothalamus damage
d. Damage to hypothalamus inhibiting production and release of NPY

18. Damage to the brain area important in regulating eating behaviour can affect hunger and satiety in two different ways. What are they?

a. overeating only
b. refusing to eat only
c. overeating, or refusing to eat
d. emotional overeating only

19. What is the role of adipose tissue?

a. stores energy for later use
b. signals the body to replenish its food intake
c. maintains the body at a healthy weight
d. carries glucose to different areas of the body

20. Dr. Burn has discovered a new hormone called DBH that he believes directly inhibits the actions of NPY. Which of the following experimental procedures would allow Dr. Burn to test his hypothesis?

a. Inject DBH into the hypothalamus; if eating increases, his hypothesis is correct
b. Inject DBH into the hypothalamus; if eating decreases, his hypothesis is correct
c. Inject DBH into the liver; if eating increases, his hypothesis is correct
d. Inject DBH into the liver, if eating decreases, his hypothesis is correct

<u>Perceived Interest Questions</u>

Please rate your agreement with the following statements based on the scale indicated: (circle your answer)

Q1: "I found the material presented in this lecture to be interesting"

<u>**1**-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree</u>

Q2: "The lecture material has a high level of difficulty"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Q3: "I found that the presentation style helped me to understand the lecture material"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Q4: "The narrator clearly communicated the material"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Q5: "The overall effectiveness of the instructor was high"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Q6: "I found the multimedia presentation (use of images and/or words) engaging"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Q7: "I found that I had a good understanding of the material overall"

1-absolutely agree **2**-mostly agree **3**-mostly disagree **4**-absolutely disagree

Depth of information processing questions

Choose the statement that was present in the lecture.

1.

a. During most of our evolutionary past, food sources were scarce
b. Food sources are no longer as scarce, so intense food seeking behaviour is no longer adaptive
c. Food sources are distributed more evenly, so are less scarce in a modern context

Answer key:

a. **Exact (shallow processing)**
b. **Deep processing**
c. **Novel statement**

2.

a. The stomach-esophagus connection was believed to be important in hunger sensations before proved otherwise
b. You begin to feel hungry when the walls of your stomach rub against each other
c. A proposed reason for hunger is when your stomach lining comes into contact with one another

Answer key:

a. **Novel statement**
b. **Exact (shallow processing)**
c. **Deep processing**

3.

a. Inglefinger discovered that the esophagus-intestine connection was important in the feelings of hunger
b. After finding that patients without stomachs still reported feeling hungry, Inglefinger concluded that the stomach was not important in hunger
c. Inglefinger concluded that the stomach does not play a critical role in the feelings of hunger

Answer key:

a. **Novel statement**
b. **Deep processing**
c. **Exact statement**

4.

a. The liver monitors and controls the major nutrients required for survival
b. A major role of the liver is the regulation of nutrients such as glucose
c. The liver is one of the major organs involved in food detoxification

Answer key:

a. **Exact statement (shallow processing)**
b. **Deep processing**

   c. **Novel statement**

5.

   a. Glucose is regulated by mechanisms in the liver and intestines
   b. Glucose plays an important role in hunger, especially the rise and drop of glucose in the blood
   c. The level of glucose in your blood is related to your feelings of hunger

Answer key:

   a. **Novel statement**
   b. **Deep processing**
   c. **Exact statement (shallow processing)**

6.

   a. You stop eating when your stomach is full
   b. Feeling full has to do with gastrointestinal juices
   c. One explanation of feeling "full" is when your stomach is physically full

Answer key:

   a. **Exact statement (shallow processing)**
   b. **Novel statement**
   c. **Deep processing**

7.

   a. CCK is a hormone implicated in feelings of satiety, because its presence usually (but not always) results in feelings of fullness
   b. When CCK is injected directly into test subjects, feelings of satiety very rapidly result
   c. CCK injections lead to feelings of satiety due to its effect on appetite

Answer key:

   a. **Deep processing**
   b. **Exact statement (shallow processing)**
   c. **Novel statement**

8.

a. It is thought that PYY works by sending signals to hunger-related areas of the brain
b. Hormones, such as PYY, are involved in feelings of satiety and hunger
c. How PYY causes feelings of satiety is still being investigated, but it most likely works by communicating information to hunger-related brain areas

Answer key:

a. Exact statement (shallow processing)
b. Novel statement
c. Deep processing

9.

a. The hypothalamus regulates hunger via communication with the stomach
b. The hypothalamus is vital in the balance between hunger and feeling full
c. The most important area in the regulation of hunger and satiety is the hypothalamus

Answer key:

a. Novel statement
b. Deep processing
c. Exact statement (shallow processing)

10.

a. Damage to the lateral hypothalamus leads to a drastic reduction in eating behaviour
b. Because the lateral hypothalamus is involved in food intake, damage results in a severe reduction in eating
c. The lateral hypothalamus is involved in the inhibition of food intake

Answer key:

a. Exact statement (shallow processing)
b. Deep processing
c. Novel statement

Experimetrix Sign-Up

Come participant in an experiment that will help us learn more about effective multimedia design. All you have to do is watch a lecture about hunger, and fill out a comprehension quiz and questionnaire. You will receive one course credit or ten dollars cash!

Informed Consent Form 2010-2011 Academic Year

How does visual information influence Multimedia Learning?

Lead Investigator: **Barbara Fenesi**, Principal Investigator: **Dr. Joe Kim**

You are being invited to participate in ongoing research conducted by Barbara Fenesi from the laboratory of Dr. Kim and the Department of Psychology, Neuroscience, and Behaviour.

Why are we doing this study?

We are conducting several studies to obtain a better understanding of how visual information should be presented in Multimedia instruction to optimize learning.

What will happen during this study?

You will complete a comprehension quiz, and a questionnaire after watching a lecture on hunger.

Will anything bad happen during the study?

This study uses traditional procedures in this type of research. You are unlikely to experience any discomfort when answering any questions. You do not need to answer questions that make you uncomfortable, or that you do not wish to answer for other reasons.

What good things could happen if I participate?

Although the research will not benefit you directly after completing the study, it will contribute to progress in educational psychology.

Who will know what I said or did in the study?

Your responses to the quiz, questionnaire and demographic information will remain confidential. Your name and student number do not need to be included in the quiz or questionnaire. All information will be stored by computer-generated code. All the paper work will be stored in a locked lab room. All the computer files will be password protected.

What if I changed my mind about participating in the study?

Your participation in this study is voluntary. You may terminate your participation at any time without penalty.

Contact

If you have any questions at any time about the study, or the procedures, please contact Barbara Fenesi fenesib@mcmaster.ca, or Dr. Kim, kimjoe@mcmaster.ca. This study has been reviewed and approved by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant, or about the way the study is conducted, you may contact McMaster research Ethics Board Secretariat, 905-525-9140 extension 23142, ethicsoffice@mcmaster.ca.

Consent

I have read and understand the above information, and agree to participate in this study. I have had the opportunity to ask questions about my involvement in this study, and to receive any additional details I wanted to know about the study. I understand that I may withdraw from the study at any time, if I choose to do so. I have been given a copy of this form

Participant's Name (Print) ____

Participant's Signature _______________________ Date _______________________

The Debriefing Form 2010-2011 Academic Year

How does visual information influence Multimedia Learning?

Lead Investigator: Barbara Fenesi

Principal Investigator: Dr. Joe Kim

A significant area of educational research involves investigating optimal ways of designing multimedia instruction to enhance learning. Previous research suggests a person's ability to actively manipulate immediate information is limited by cognitive resources. If the instructional method requires more cognitive resources and attention than is available, learning will be impaired (Mayer & Moreno, 1993). Our study will examine how varying the amount and type of visual information during a computer-based lecture affects a participant's ability to learn complex material. We will manipulate the presence and amount of text and images. A consistent audio track will be used. Immediately following the lecture, we will test comprehension, and perceived interest of the lecture. Two domains of comprehension will be examined. The first domain will test basic retention of material. The second domain will test a deeper understanding of material. For educational courses such as Psychology, a deeper and applied understanding of material is desired. However, in a course such as Anatomy, perhaps basic retention of anatomical units is desired. Therefore, the results of this study will become particularly useful for creators of multimedia design wishing to optimize different domains of learning.