Dietrich College Honors Thesis

PowerPoint Visuals in the Humanities

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Abstract

In recent years, PowerPoint presentations have become the medium of choice for high school and college educators. Research on images in these presentations has determined that relevant diagrams and graphics improve learning in science and engineering fields; however, there has been little research on images in the humanities, where diagrams are less common. This study first surveyed college students to determine which images are considered informative and which are considered decorative. Using these results, I presented a new group of participants with humanities content accompanied by different image types. Participants then took a quiz on the content. Quiz results seem to indicate that the images deemed "informative" and text-only slides aided retention the most. A surprising finding was how often SmartArt and images accidentally contradicted the slide's main ideas and hurt retention. This finding could help educators and presenters avoid using contradictory or backfiring visuals. This report concludes with a recommendation for a usability test that presenters can use to assess the efficacy of their slide visuals.

Introduction

With the multitude of professors and student presenters using PowerPoint slides, combined visual and verbal learning has never been as common in academia as it is currently. These presentations are used across a wide variety of disciplines, from engineering to art history. Slides from these presentations can also be screen captured along with voice narration to create educational videos. Due to its growing use, PowerPoint slide design has been a popular subject of research in both pedagogy and cognitive science.

Despite its prevalence, most PowerPoint presentations are ineffective and often criticized. Alley et al. note several illustrative headlines in their article about slide design: "PowerPoint is Evil" (*Wired*), and "Is PowerPoint the Devil" (*The Chicago Tribune*), for instance ("Common Use of PowerPoint" 331). Default settings in PowerPoint itself cause many users to crowd slides with text and use ineffective phrase headings (Alley et al, "Common Use of PowerPoint" 334). The common use of long bulleted lists not only increases the audience's cognitive load, but also fails to show any logical relationships between

pieces of information. Overall, PowerPoint's common practices are not helping audience retention or comprehension.

Multiple studies have found that the most important aspect of the slide is the sentence heading. Rather than the commonly used phrase heading, which simply states the topic of the slide, these headings use a full sentence to explain the main idea and actually assert something about the topic. Alley et al. found that these commonly used phrase headings actually obscure connections between informational elements ("Common Use of PowerPoint" 337). Further, in a study that compared two different sets of slides for the same content, engineering students remembered content better when they had viewed slides with a sentence heading versus the phrase heading (Alley et al, "Design of Presentation Slides" 1576). In their book *Slide Rules*, communications professors Traci Nathans-Kelly and Christine G. Nicometo similarly support a full sentence heading that asserts something about the information presented, not just states the subject. These experts and researchers suggest many guidelines for effective slides, but the sentence-heading appears to be the most important aspect.

While Alley et al. found that the sentence heading is crucial for audience understanding, there is a large body of research to support the use of images. It is generally agreed that pictures are more memorable than words. Levin et al., in their research on pictures in prose, argue that memory for pictures is better than that for verbal information because of their concreteness (Levin et al. 60). Joan Peeck's research on picture-supplemented text versus text-only information also indicates that pictorial information is better remembered; students who read the illustrated text performed better on her test than those who read text without illustrations (Peeck 126). These findings are supported by the idea of dual encoding; information stored in both visual and verbal memory is better remembered than information stored through only one medium. Levin mentions that illustrations take verbal information and represent it in another mode, while Peeck agrees with the idea of two different memory stores, one visual and one verbal (Peeck 128). This research generally agrees that images are helpful for learning.

Though this research focused on text illustrations and static image slides before the existence of dynamic slide presentations, this same idea of dual encoding has been reiterated in the context of slide

designs during modern presentations. More recent pedagogical research has determined that the use of images, charts, and other visuals aids audience understanding and memory of PowerPoint slides. Revising slides to use images more effectively helped to improve short-term retention in a study by Issa et al. They compared medical students' retention when taught using traditional, text-heavy slides versus revised visual and verbal slides. Results indicated that the revised slides improved short-term retention in the undergraduates, but further evidence is needed to determine if this same effect occurs for long-term learning (Issa et al. 824). In another study that compares the effects of various kinds of visuals on student learning, Doris Lewalter used a computer-based learning text to examine the effects of text-based content versus text with static images versus text with dynamic images. Lewalter concluded that both types of visual content helped students store information in memory more effectively than text-only content (187). Both Issa et al. and Lewalter's research indicates that images enhance students' learning.

Despite the general consensus that PowerPoint images improve audience learning, many experts warn that not all visuals are equal. Experts agree that there are both dangers and advantages to visuals in PowerPoint. For example, in his overview of slide design basics, education and training specialist Brian Sloboda says that visuals such as pictures, charts, and videos have the potential to both enhance and hurt a presentation. More specifically, he notes that images should match what the speaker is saying, but he also cautions against distracting logos or other images that appear on every slide (Sloboda 27). Similarly, communications professors David Levasseur and J.Kanan Sawyer conclude that images can aid student learning when designed properly, but they also warn that irrelevant graphics could distract an audience more than enhance their learning (Levasseur and Sawyer 116). In a different field, biostatistics and measurement professor Ronald A. Berk instructs readers on a variety of aesthetic decisions, including how to choose images to accompany the slide's text. He, too, notes that these images should be bold and colorful, but closely related to the presentation's narration (Berk 29). In their study of commonly used PowerPoint techniques, Alley et al. asserted that visuals should explain the information on a slide (Alley et al, "Common Use of PowerPoint" 339). When this sort of image is not available, one that "represented or identified" the main topic of the slide could be used, but this could also hamper the audience's

understanding of the main idea of the slide. Though all of these experts recommend the use of images, they seem to agree that they must be chosen carefully to match the presentation's content.

Corroborating these expert claims that visuals need to be carefully chosen for relevance, studies of both slide design and computer-based textbooks have found that students learn more based on how closely the image related to the presentation content. To determine what defines the proper use of images in visual and verbal learning, cognitive science research has looked closely at the relationship between words and pictures. One image that has been consistently deemed relevant are cause and effect diagrams, which visually show the relationships between ideas or objects (Harp and Mayer 92; Mayer, "Promise of Multimedia Learning" 136; Tangen et al. 870). This is compared to other images such as simple pictures or decorative clip-art. Other studies examined different types of visuals and found that students learn better depending on how closely the image relates to the presentation's content. Jason Tangen et al. concluded that slideware presentations with relevant images lead to better learning outcomes than text-based slides (865). An incongruent image was defined as one which pertained to narration but not to the information of the slide. In their study of an undergraduate psychology course, Tangen et al. compared image-congruent slides versus text-based slides versus image-incongruent slides. Interestingly, though students were more interested in both image-based presentations, they learned information more accurately when taught with image-congruent slides compared to image-incongruent slides. Further, even text-based slides lead to more accurate learning than image-incongruent slides (Tangen et al. 870). Overall, these mixed results for slide images seem to indicate that relevant visuals are helpful, but irrelevant visuals can hurt audience retention.

This advice to include only relevant images may be straightforward in science and engineering disciplines; however, it is more difficult to implement in practice. The difficulty to define relevant images, on the other hand, has been highlighted in other studies. Jo Mackiewicz tested many of the PowerPoint expert opinions against those of college undergraduates. Both students and experts agreed that visuals are a powerful component of PowerPoint (Mackiewicz 161). However, even though the surveyed students were from fields such as engineering, computer science, and technical communication,

they found choosing such visuals difficult. They noticed that finding the correct balance of text and images was very difficult because too many images can be distracting and overwhelming. This came from their own experience as the audience of numerous professors' presentations. In other words, real world studies with undergraduate college students show that experts' advice about images does not entirely help in practice.

Though they warn against irrelevant or inappropriate images, the experts still leave those in more conceptual fields, such as the students in communication, to wonder what constitutes a relevant visual. A vast majority of pedagogic and cognitive science studies have focused primarily on scientific content; humanities presentations have not been extensively researched. In science and engineering, where cause and effect diagrams are often available and process visuals are easy to create, it appears easy to determine a relevant visual from an irrelevant one. For example, in the study by Tangen et al., they used content from physics where the narration said, "Light travels in waves that code for the scene we're viewing" and the relevant slide showed an image of light waves traveling to the eye. The irrelevant slide, on the other hand, showed an image of computer code. This difference is fairly easy to see. Though this study concludes that cause and effect images can help students learn a process, these images are not available for a humanities subject such as English composition or history. Instead, many presentations use conceptual or decorative images that relate to the topic. In the context of scientific fields, these graphics may not seem as related to the content of a lesson, but perhaps they are considered relevant in a more abstract discipline.

For more abstract information, educators may turn to more conceptual images to create visual analogies. Analogies in general have been deeply studied in education. Kendall-Taylor et al., in their research on metaphors to explain scientific concepts, say that metaphors can make a complicated concept more understandable through concrete, familiar comparisons. The important aspects of a complex idea can be mapped onto these more familiar concepts to help learners "organize information into a clear picture in their heads" (Kendall-Taylor et al. 416). In their cognitive psychology research on analogies, Gentner and Smith corroborated many of these ideas, but warn that analogies should emphasize the

similar relationships between the compared systems, not surface similarities. These surface attributes are easier to match, and learners tend to focus on them instead of the important relational features (Gentner and Smith 11). Research about analogies in learning can be applied more specifically to visual analogies as well. In his review on image research, Levie argues that pictorial analogies aid learning because they "make abstract information more concrete and imaginable" (Levie 18). These visual metaphors seem similar to the relevant cause and effect visuals recommended for science and engineering fields.

Though studies have shown that cause and effect diagrams and graphics that illustrate a process lead to better retention in students, we do not know if the same is true for more conceptual, visual analogy images such as the one in Figure 2. Research on analogies seems to suggest that such images could help students retain information by making the abstract more concrete, but we do not know if this idea applies in the context of PowerPoint presentations.

For instance, a conceptual slide such as the one in Figure 1 might be used in a non-scientific context where logical, explanatory diagrams cannot be applied. The slide shows a pyramid with multiple levels to represent the social hierarchy of ancient Egypt. The slide's heading says, "Ancient Egypt's culture followed a distinct social hierarchy based on wealth." Humanities presenters use these conceptual images in an attempt to follow expert advice about effective slide design; however, as Mackiewicz's study shows, deciding what is considered informative can be very difficult. The pyramid does relate to the idea of hierarchy, but perhaps this image would only garner interest and distract from learning, as Harp and Mayer suggest.

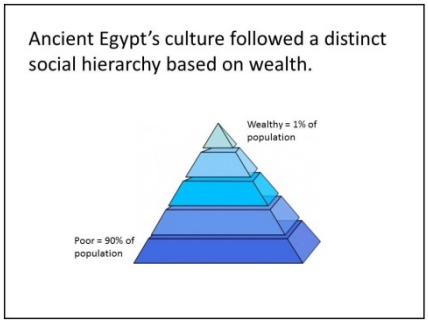

Fig. 1

One way of creating visual metaphors is through SmartArt, a graphics option in PowerPoint that can visually relate text through flowcharts, diagrams, and other process illustrations. Figure 2 shows examples of SmartArt.

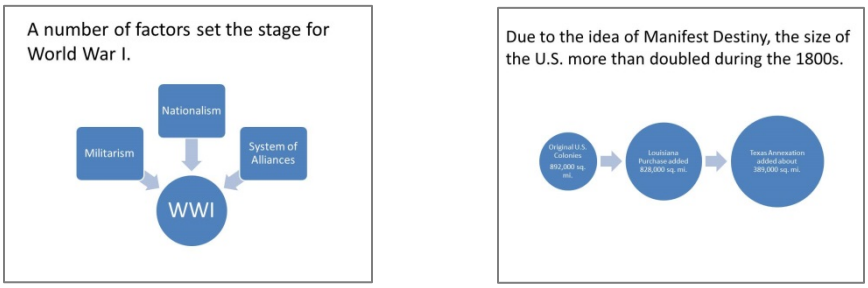

Fig. 2

It has not been extensively studied, but SmartArt can be used to show relationships in more abstract humanities topics. The simplicity of SmartArt even follows best practices for images; in his review of psychology and education research on pictures, W. Howard Levie concludes that line drawings are more helpful in presentations, while realistic images are more effective in formats where study time is unlimited (16). Similarly, in her review of image literature, Peeck suggests that less detailed pictures have less potential to distract viewers from the important aspects of the image, and are therefore better for situations with time constraints (138). In other words, less detail is good. SmartArt presents a way to show information visually and with less line and shape details.

However, it is not clear how to classify SmartArt visuals. On the one hand, it could aid retention by visually showing relationships in a simple way, as in the effective cause and effect diagrams promoted by experts in science and engineering communication. On the other, it could potentially backfire if it oversimplifies or overcomplicates a slide's main idea, which could be easy to do for abstract information. Without extensive research, many questions remain about SmartArt. Is it conceptual or decorative? Is it considered relevant? Does it aid audience retention?

This research seeks to determine what types of images should be included in humanities PowerPoint presentations to aid audience retention. Specifically, it compares conceptual images, decorative images, SmartArt, and no image at all. By comparing these images, I hope to determine what

is considered "relevant" for humanities subjects. I also seek to understand how decorative images affect retention. Lastly, I hope to define where SmartArt fits into these image categories and how it affects retention.

Phase I Methods

To answer these research questions, I conducted a study in two parts. The first surveyed undergraduate and graduate students to determine what kinds of images are considered informative in humanities course contexts. The purpose of this phase was to gain insight into student perceptions of humanities images and verify that the conceptual images chosen are considered informative. The second phase tested these images to see which ones aided retention most effectively.

Slides

In order to put the images in context, I chose four humanities subjects and created a set of three slides for each. The subjects and their sentence headings are listed in Table 1. Subjects were selected to represent a variety of humanities fields for which visuals might be difficult to select.

TABLE 1: Slide subjects and sentence headings

Subject	Slide Heading
World History	Ancient Egypt's culture followed a distinct social hierarchy based on wealth.
Business	Competition can motivate your employees and push your company.
Psychology	Metacognition is the process of thinking about thinking.
U.S. History	Due to the idea of Manifest Destiny, the size of the U.S. more than doubled during the 1800s.

For each set, the heading was consistent, but each slide used a different image. The images were tentatively categorized as "conceptual," "decorative," and "SmartArt." These images were used on slides

that adhered to experts' advice on visual and verbal presentations. Figure 3 shows examples of the conceptual image slide for each subject. See Appendix A for all other slides.

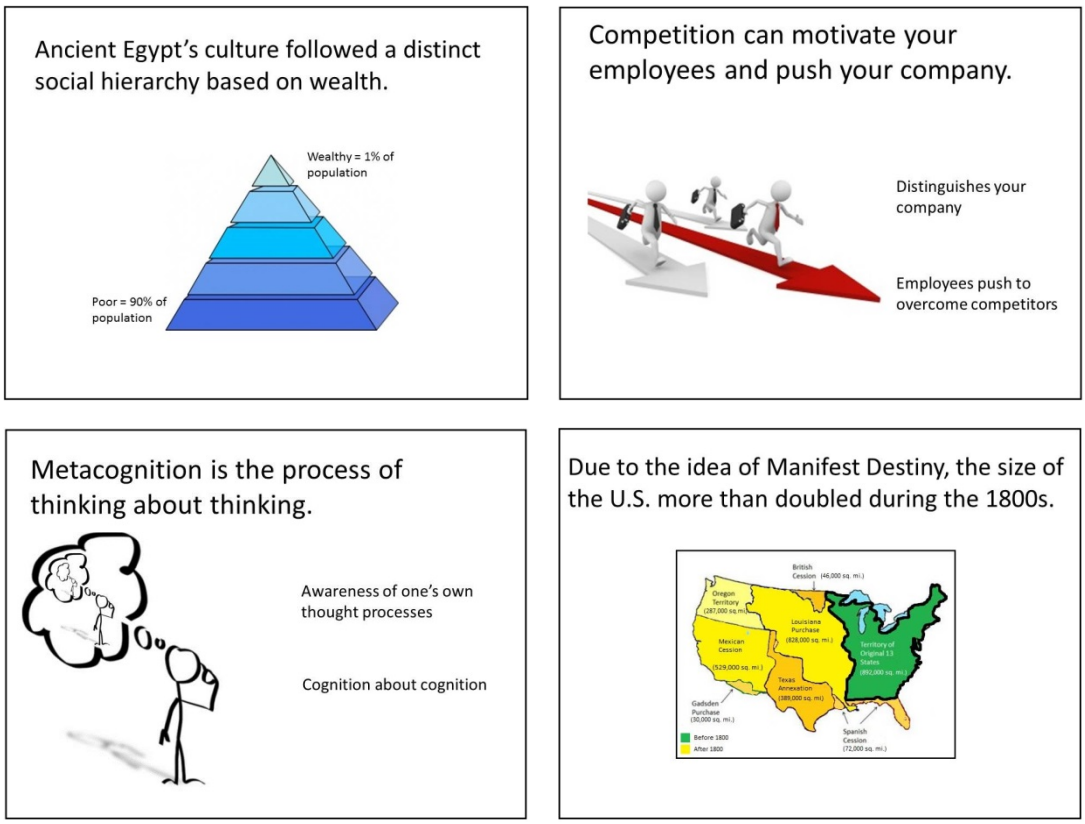

Fig. 3

The conceptual slides were intended to create visual analogies for their main headings. The Egypt conceptual slide shows a segmented pyramid to represent the class hierarchy in Egyptian society. The competition slide shows corporate figures racing each other. By reusing the same image multiple times, I created the metacognition image to show a stick figure thinking a thought bubble about himself thinking, which contains another thought bubble of himself thinking. Lastly, the Manifest Destiny slide shows a map of the United States divided into the original thirteen colonies in green and the additional territories acquired during the nineteenth century in yellow.

The decorative slides were intended to represent, but not explain, some aspect of the slide's information. For example, the Egypt decorative slide shows an ancient mural of a slave serving a

wealthier person. The competition image shows a man in a suit trying to climb a ladder while other business men and women try to follow him, which is intended to show corporate competition. The metacognition image is a picture of "The Thinker" statue to represent the thinking involved in metacognition. The Manifest Destiny decorative image is the painting *American Progress* from 1872, which was intended to represent the setting of the western U.S.

SmartArt diagrams were created to explain the slide's main idea through text, shapes, and lines. For the Egypt slide, the SmartArt diagram is made up of two rectangles of text, one large and one small to represent the disparity in class sizes. The competition SmartArt shows a cause and effect chain that starts at the bottom with "competition" and ends at the top with "innovates and distinguishes your company." For metacognition, the SmartArt shows a large oval that says "thinking" with an arrow pointing from it to another identical bubble. Lastly, for Manifest Destiny, the SmartArt shows a series of growing bubbles that represent the territorial additions that eventually doubled the size of the U.S.

These slides followed the assertion sentence headings recommended by Alley et al. By clearly stating the assumptions and connections in the topic, these headings reduce the cognitive load on viewers (Alley et al, "Common Use of PowerPoint" 342). In other words, rather than simply state a topic such as "Egyptian Social Structure," these headings assert information about Egyptian society (in this case "Ancient Egypt's culture followed a distinct social hierarchy based on wealth"). The headings follow the Alley et al. recommendations further by taking up no more than two lines on the slide.

Participants

I then distributed an online survey through Carnegie Mellon University Facebook groups. Participants had to confirm that they were over 18 years of age and current CMU undergraduate and graduate students. In the end, 51 students participated in the survey. Although many chose not to provide demographic information, most participants were from engineering majors or computer science (30% each). Table 2 shows the breakdown of all majors. Most were female (74%), and the majority of

participants were freshman or sophomores (33% and 30% respectively). Table 3 shows the breakdown of all class years. The vast majority of participants were native English speakers (97%).

TABLE 2: Phase I participant majors

Major	% of Participants
Engineering	30
Social sciences	9
Humanities	18
Natural sciences	9
Computer science	30
Other	3

TABLE 3: Phase I participant class years

Year	% of Participants
Freshman	33
Sophomore	30
Junior	9
Senior	24
Graduate	3

Procedures

Participants were asked to rate all twelve slides using a Likert scale (options included "very," "somewhat," "a little," and "not at all"). Slides were grouped by subject, but their order was randomized so that participants did not see the same order of image types (conceptual was not always first, etc.). They rated the images based on the following factors:

How informative is this slide's image?

How much does this image aid your understanding of the slide?

How much does this image motivate you to pay attention?

To what extent is this image distracting?

To what extent does this image make the slide's content more memorable?

After rating each slide for a subject, participants were asked to choose the most and least informative slides for that subject and explain their choices. At the end of the survey, they were asked to provide some demographic information.

To analyze these results, I averaged the Likert scores for each image type (conceptual, decorative, SmartArt), where 4 represented "very" and 1 represented "not at all." Within each subject, I determined which image was most informative based on participant rankings. For open response answers, I coded each one based on their explanation for why they ranked the images the way they did. I looked for reasons such as "confusing," "distracting," "contradictory," and "appealing."

Phase I Results and Discussion

Overall, participants selected the images intended to be conceptual as the most informative (see Figure 3). Table 4 shows the average Likert scale scores for all three image types. A notable result from the survey is that the images deemed most informative were also perceived as more motivating, memorable, and helpful for increasing understanding. As Table 4 shows, the conceptual image group had the highest average scores for understanding, motivating, and memorable. This result seems to confirm that the images are relevant to the slide's content, and it also suggests that the images will aid audience retention.

TABLE 4: Average Likert scores for each subject. Minimum is 1 ("not at all"). Max is 4 ("very").

AVERAGE	informative	understanding	motivated	distracting	memorable
conceptual	2.94	2.79	2.49	2.04	2.71
decorative	2.13	1.98	2.04	2.15	2.11
smart art	2.39	2.22	1.91	1.93	1.95

The conceptual image with the highest score for "informational" was that of metacognition, shown below in Figure 4.

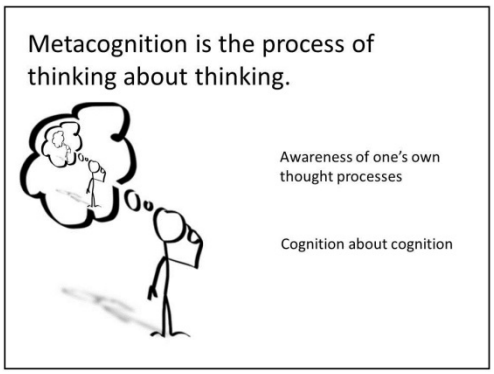

Fig. 4

The average "informational" score for this image was a very high 3.24, while its "distracting" score was a very low 1.7. Regarding this image, participants said:

> The stick figure is clear and unobtrusive in showing nested thought, while being cute enough to be memorable as well.
>
> The thinking stick figure is the most helpful visual indication of what metacognition actually entails, because we can see a sort of process as the drawing is repeated in the thought balloons.
>
> Thinking stick figure was most helpful in visualizing the concept.

Clearly participants had no trouble seeing relevance in this particular case.

The conceptual image for Manifest Destiny also performed well an average score of 3.61 for being informative and 3.39 for helping understanding. In reference to the conceptual and decorative images for Manifest Destiny, one participant said, "the map is the most informative because it gives a visual representation of the territory expansion. The painting is the least informative because it doesn't give any sort of representation of the numeric values of territory expansion." For these three cases, the results are statistically significant (understanding: p=0.0394, motivating: p =0.0143, memorable: p =0.0026). These positive comments regarding the conceptual images suggest that participants would prefer to see this image type over the others.

Although conceptual images scored higher than other image types, scores tended to cluster around the middle values ("somewhat" and "a little"). One likely explanation is that relevance is less obvious in humanities images. As noted in the outset of this research, humanities images are more difficult to classify as relevant and irrelevant. Another explanation might be that participants were more critical of these images than they might be normally. Because they were taking a survey entirely focused on PowerPoint images, they were likely more meticulous in their analyses than they would be during a class lecture. This might also explain the cluster of middle values.

The survey results further suggest that SmartArt is not only less motivating, but also less memorable than the other slides. As Table 4 shows, SmartArt had the lowest average score for both motivating and memorable. In the case of the metacognition slides, for example, about 38 percent of

participants who provided an explanation for their choices said that the SmartArt was confusing (for further details of open response answers, see Phase II: Results and Discussion). In reference to the metacognition slides, one participant said, “Ovals [SmartArt] needed more thinking to understand the image's relevance.” Compared to the other two image types, SmartArt’s lower memorability score is marginally statistically significant (p=0.0774). Although the difference in motivation scores was not statistically significant, the general trend seems to suggest that participants did not find SmartArt visuals very interesting. These results lend support to the idea that SmartArt does not help the audience retain content or add visual interest to the slide.

At the same time, they seem to show that SmartArt is considered less distracting. It was also ranked more highly than decorative images for being “informative” and “helping understanding.” This suggests that decorative images might be more distracting and less informative than SmartArt, even if they are more motivating and memorable.

Phase II Methods

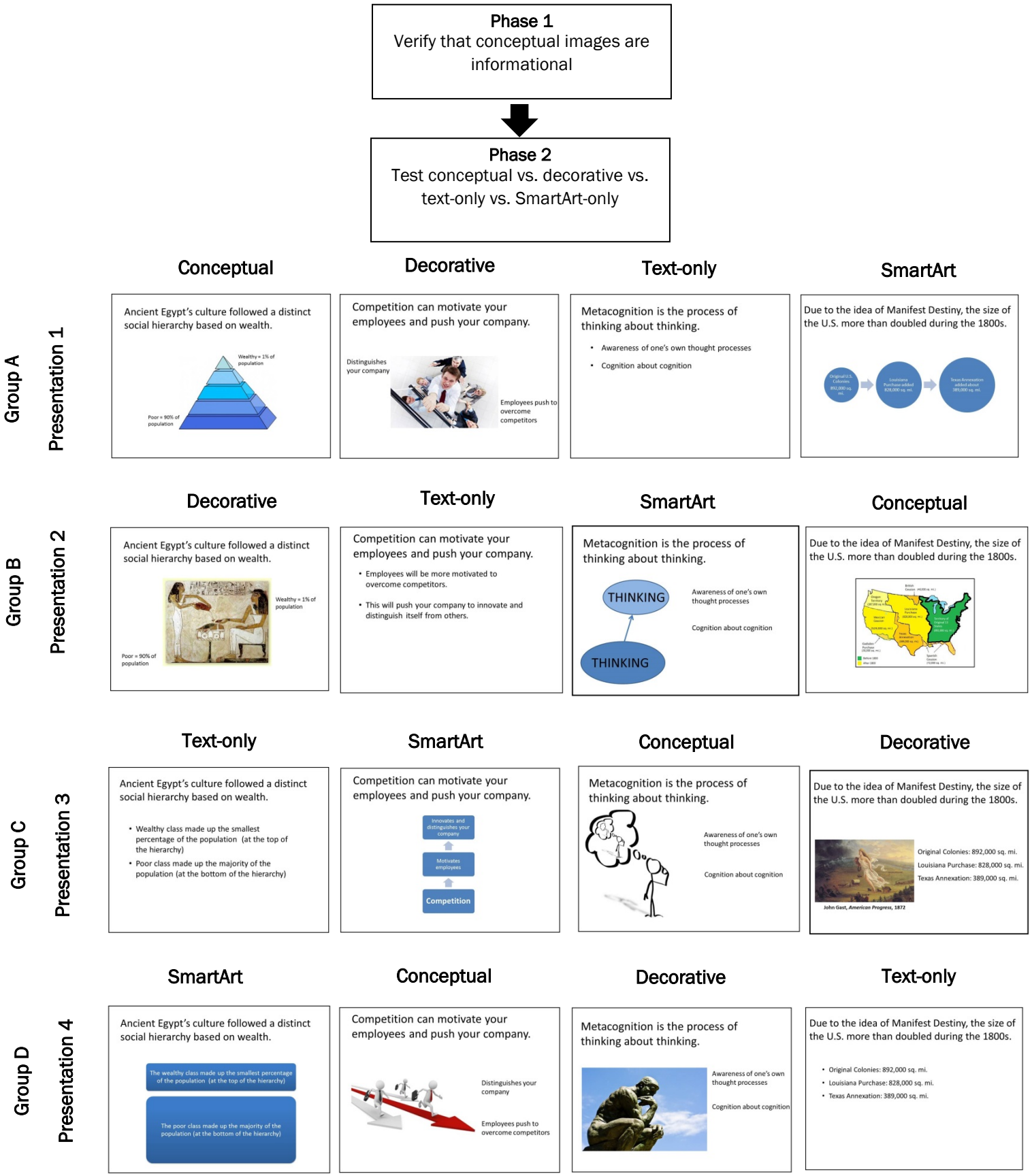

Fig. 5

In Phase I, participants ratings aligned with my categorization of conceptual and decorative images. The conceptual images were rated as the most informational. To test the relevancy of the images from Phase I, Phase II of this study compared students' short-term retention of concepts taught with informative images, decorative images, text-only slides, and SmartArt. Text-only slides were included in this phase because other research has indicated that it might actually perform better than decorative images. To test these claims in a humanities context, text-only slides were used in comparison to the other three image types.

In preparation, I created four PowerPoint presentations that presented the same concepts that were used in Phase I of the study. The slides' design, however, differed for the four sets. Figure 5 shows the slides that were seen by each group. With this design, each group saw a mix of image types. This ensured that if one group was particularly good at memorization, their performance would not benefit just one image type.

Participants

These four different presentations were then shown to four different groups of six students (N=24). The students were from a range of fields of study, but all were native English speakers in order to control as many variables as possible. Anyone surveyed in Phase I of the study could not be part of Phase II because they would have seen the slides before and perhaps remember their content.

Out of the 24 participants, 15 were female and 9 were male. The majority were freshman. Table 5 shows the breakdown of participants' years by group. Most were also engineering majors. Table 6 shows the breakdown of participants' majors by group.

TABLE 5: Participant class years by group

Year					
Group	**freshman**	**graduate**	**junior**	**sophomore**	**Grand Total**
A	3	1	1	1	6
B	3	1	2		6
C	1	2	2	1	6
D	3	2		1	6
Grand Total	**10**	**6**	**5**	**3**	**24**

TABLE 6: Participant majors by group

Major							
Group	**computer science**	**economics & statistics**	**engineering**	**humanities**	**natural sciences**	**social science**	**Grand Total**
A		1	2	1	2		6
B			4	1		1	6
C	1		3	1		1	6
D	1		1	2	1	1	6
Grand Total	**2**	**1**	**10**	**5**	**3**	**3**	**24**

Procedures

Rather than use a human presenter to narrate the slides in person, the presentations were recorded using screen capture. The audio component was identical for each of the four presentations. The script for the audio presentation can be found in Appendix D. Additionally, the amount of time participants could look at the slide was also identical (participants were instructed not to pause the presentation, and then they were supervised throughout viewing). This way some human variation was eliminated from each group's session. The first group was shown presentation 1, the second, presentation 2, the third, presentation 3, and the fourth, presentation 4. In this way, each group learned the same content from each slide, but the images on the slides were different or not there at all.

In addition to the four subjects tested in Phase I, I also padded the presentation with four slides that participants would not be tested on later. These subjects were omnivores, adverbial clauses, elliptical clauses, and the Battle of Gettysburg. There was only one version of the slides for these subjects, and they were placed between those

slides from Phase I in order to add more substance to the presentation and better mimic a longer lecture. These slides are shown in Appendix B.

Once participants viewed the presentation video, they took an online quiz to test their retention of the concepts. For each subject there were four questions. The first question in each set asked about the slide's heading, and the other three asked about content both on the slide and in the verbal presentation. Questions were a mix of fill-in-the-blank and multiple choice. For example, the questions about ancient Egypt were as follows:

What was ancient Egypt's social structure based on?

Which profession belongs in the middle classes of ancient Egypt?

Approximately what percent of ancient Egypt's population was considered poor?

In ancient Egypt, social mobility was possible and most commonly achieved through:

The complete quiz is shown in Appendix C. After the four sets of subject-specific questions, participants were asked for demographic information.

Phase II: Results and Discussion

Overall, Phase II results seem to show that text-only slides and conceptual image slides were the most effective for fact retention. SmartArt slides were the least effective. Table 7 shows these quiz results.

TABLE 7: Phase II quiz scores by subject. Minimum score is 0. Maximum score is 4.

Image Type	Egypt	Competition	Metacognition	Manifest Destiny	Average
Conceptual	3.2	3.8	3.5	3.2	3.4
Decorative	2.8	3.5	3.7	3.1	3.3
Text only	3.0	4.0	3.3	3.4	3.4
Smart Art	2.3	3.8	3.0	2.8	3.0

There are no statistically significant differences between total quiz results for each type of image. There is, however, a clear pattern of SmartArt performing worse than other image types, including text-only slides. With the exception of the Competition questions, SmartArt participants had the lowest quiz scores. This trend seems to suggest that SmartArt can backfire easily, and should be used carefully in PowerPoint slides. This result will be discussed in more detail below.

Table 7 shows that conceptual and text-only performed the best on average. Text-only slides performed better than expected. Quiz results show that text-only slides tied for the best average, and they consistently performed better than SmartArt and images that contradicted the slide's main heading. This result is interesting because SmartArt slides and text-only slides were identical or nearly identical in text content, but SmartArt's quiz scores were all lower than those of text-only slides. Text-only slides and decorative image slides performed similarly in most cases, but text-only slides performed better when the decorative image contradicted the slide's main heading. These results support the idea that slides support retention more effectively without conflicting images or potentially confusing SmartArt visuals. In other words, results show how easy it is for decorative images and SmartArt to backfire.

1. **SmartArt slides can easily backfire if they are too complicated or contradict the verbal presentation.**

Phase II results seem to suggest that SmartArt slides can backfire if they do not completely agree with the verbal presentation. This can occur even in cases where the SmartArt appears to illustrate the main heading. For example, in the case of the Egypt slides, the average score with the text-only slide was 3.00 while the average score with the SmartArt slide was 2.33. The two slides are shown below in Figure 6. Interestingly, in a case where the text content was identical, the text-only slide performed better than the SmartArt slide.

Specifically, participants in the SmartArt slide group scored poorly on two questions. One, "Approximately what percent of ancient Egypt's population was considered poor?" is directly related to both the visual and verbal presentations on both slides. Participants in the text-only group all answered

the question correctly; however, in the SmartArt group, only 66 percent of participants answered correctly. This question asked for the specific number that was given verbally during the presentation.

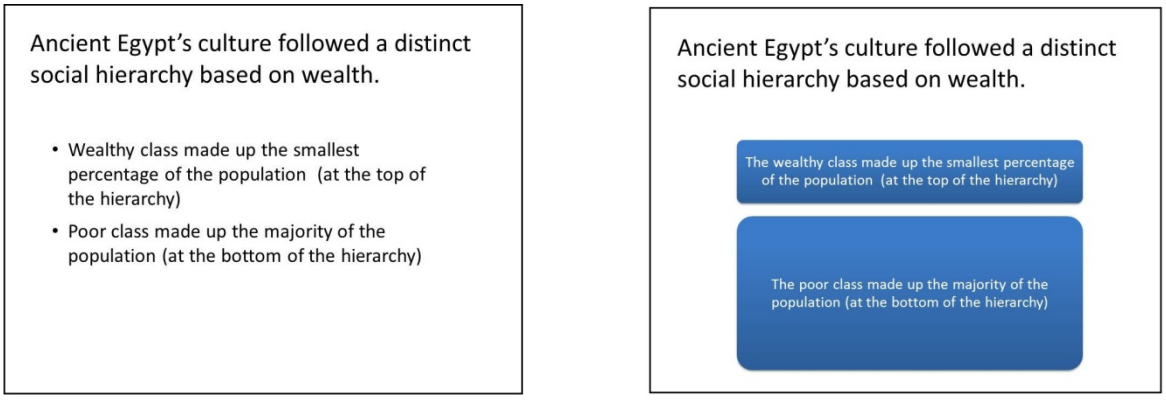

Fig. 6

In both slides, the general trend of the population sizes is given, but not the specific number. In fact, the text content of both slides is exactly the same. The SmartArt slide shows the wealthy and poor classes proportions in text bubbles. Although the SmartArt initially appears to agree with the general assertion of the heading, it then contradicts the precise percentages and the verbal information about the middle classes. In Phase I, several participants made similar observations, commenting:

> The boxes while add a sort of visual element do not convey the hierarchy as accurately as the pyramid…
>
> The boxes just reword the above expression.
>
> Boxes aren't mathematically valid AND have no connection to Egypt.
>
> The boxes distract from the text.

Such comments from Phase I seem to predict the poor SmartArt results from Phase II. The text-only slide's superior performance appears to suggest that SmartArt can backfire easily.

As with the Egypt slides, participants who saw the SmartArt Manifest Destiny slides performed poorly. This trend is shown in Table 7. In this case, the SmartArt image emphasized the overall size change of the U.S., but did not visually show the individual sizes of the territories. Therefore, when SmartArt participants were told, "Rank the following territories from largest to smallest (top=largest,

bottom=smallest)," they performed poorly. Overall, the average score for SmartArt participants was 2.8, while that of text-only participants was 3.4. The two slides are shown in Figure 7.

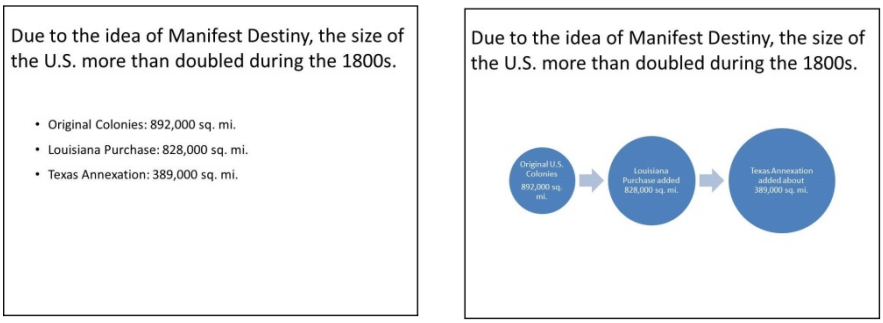

Fig. 7

Looking at the slides, we can see that in the SmartArt slide, the overall national size change is shown, but the size of the individual territories is difficult to discern and not accurate. At first glance, it might also appear that each individual bubble represents the territory's size, when it actually represents the total size of the U.S. Unlike the Egypt SmartArt, the Manifest Destiny SmartArt does convey the main heading. In the Manifest Destiny case though, the verbally given idea of the individual territories' size is confused. When asked to rank the size of the Louisiana Purchase, the Texas Annexation, and the Original Thirteen Colonies, SmartArt participants answered correctly only 33 percent of the time. Compare this to the text-only slide, with which participants answered correctly 83 percent of the time. In Phase I, many participants commented on this confusion:

> The circles is [sic] actually deceptive. If each circle actually represented the area of the US after each annexation, it might be helpful. But it just looks like 3 unrelated circles.
>
> The circles would make better sense if the total square mileage was included, not just the added square mileage (the bigger circles for smaller numbers is confusing at first).
>
> Circles - it's a nice, clean image, however... it can get confusing for some people because it's not clear that the territory "doubled" with the image... and people might wonder "why are there three circles....are some purchases just bigger than others?

These comments show that even without the audio presentation, participants noted the SmartArt's confusing display of the individual territories.

For the Metacognition slides, SmartArt also performed poorly. In this case, the SmartArt may have been too complicated and taken too long to puzzle out. This might explain why SmartArt participants performed much worse than other image type participants on an audio-reliant question. This question, "What was the name of the researcher who suggested reflective journaling after an exam?" could only be answered if the participant listened carefully; it was not visually presented. SmartArt participants answered correctly only 33 percent of the time, while those from other image types answered correctly about 50 percent of the time on average.

Looking at the SmartArt slide, we can see that the image does not contradict the heading, but it does not seem to clearly explain it either. Phase I participants noted this lack of clarity in many of their comments and their rating of the image's motivation and memorability. On a scale from 1 to 4, 1 being "Very" and 4 being "Not at all," the metacognition SmartArt slide averaged a rating of 3.45 for motivation and 3.33 for memorability. In their comments, Phase I participants said:

> The ovals don't really give any extra information at all and are just kind of confusing.
>
> The ovals are not helpful. If metacognition is thinking about thinking, an arrow doesn't really indicate "about" so much as it indicates consequence.
>
> The ovals image is very unclear. An arrow between the words thinking does not describe the word metacognition very well.

Between the motivation and memorability ratings and their comments, Phase I participants seemed to accurately predict the metacognition SmartArt's poor quiz performance in Phase II. Excluding the results from the competition slides (where scores for text-only, conceptual , and SmartArt were all nearly perfect, suggesting that the questions were too simple), SmartArt performed significantly worse on average compared to the other three image types. Again, excluding the competition results, its average score was 2.7 while the average of the other three image types was 3.27. This result is statistically significant (p=0.0255). Overall, this result suggests that SmartArt can backfire easily.

The result does not, however, help us define SmartArt into an image type. Its performance was significantly poorer than conceptual images, which seems to show that is it not a "cause and effect" process diagram such as those in science disciplines.

2. **Decorative images do not affect performance *unless* they contradict the slide's main idea; however, it is easy to accidentally do so.**

Phase II results appear to support the idea that decorative images are harmless as long as they do not conflict with the slide's main heading. For example, the decorative image only appeared to hurt performance in the competition slides, where the decorative image participants scored an average of 3.5 on the quiz and the average score from the other three image types was 3.89. This result was statistically significant (p =0.047). Table 7 shows that for all other subjects, the decorative image performed just as well as the average or better.

For the competition slides, one likely explanation for this is that the decorative image hurt performance because it contradicts the slide's main idea. Looking closely at the slide shown in Figure 8, at first glance it seems to relate to the general theme of corporate competition.

Fig. 8

Instead it actually depicts cutthroat, negative competition on the ladder. In reality, the main idea of the slide is that competition can benefit your company in many ways. Participants from Phase I predicted this result in many of their comments, such as:

Without context, the ladder image is just kind of weird and distracting. Also the competition seems more cutthroat in this picture, which contradicts the slide information.

Ladder just doesn't make sense to the analogy.

The image is just filler and does not directly relate to the slides [sic] message.

The ladder gave no info and just confused me.

These comments support the idea that the decorative image in the competition slides is hurting performance because it opposes the slide's main idea.

Compare this result to that of Manifest Destiny, where Table 7 shows that the decorative image participants scored an average of 3.08 and the other image types scored an average of 3.11. I hypothesize that this much closer result is because the decorative image does not contradict the slide's main idea, but is related to it. The slide is shown in Figure 9.

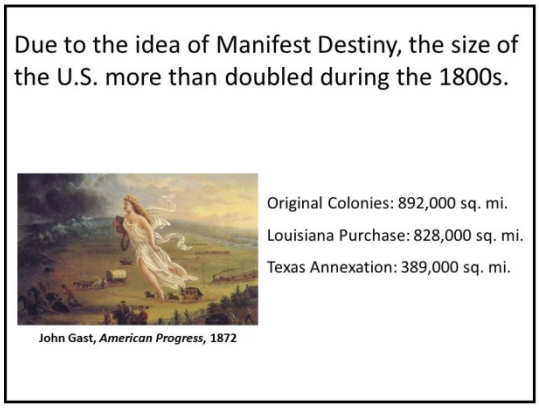

Fig. 9

Again, Phase I participants seem to predict this result in their comments, though opinions were mixed. Though many rated it as distracting, the image also received high scores for motivation and informational. For instance, some said:

…the painting gave an idea of the cultural feel of Manifest Destiny.

> In regards to the Painting, it's [sic] meaning is not as obvious. You'd have to interpret it and understand how it represents the Manifest Destiny but in the end, this will probably help remember the information better.

If we compare these comments to those about the competition decorative slide, we can see how these different initial interpretations could be used to predict the drastically different quiz results in Phase II.

3. Conceptual images are never hurting performance.

Table 7 shows that conceptual images tied with text-only for best quiz performance. Additionally, it shows that performance was fairly consistent across all subjects. In every case, conceptual image participants scored either the highest or second-highest compared to other image types. This seems to indicate that images conveying the slide's main heading usually perform well. Looking closer at the conceptual image slides, we can see how the image not only relates to the slide's main idea, but also explains it in a visual metaphor. The conceptual images are shown below in Figure 10.

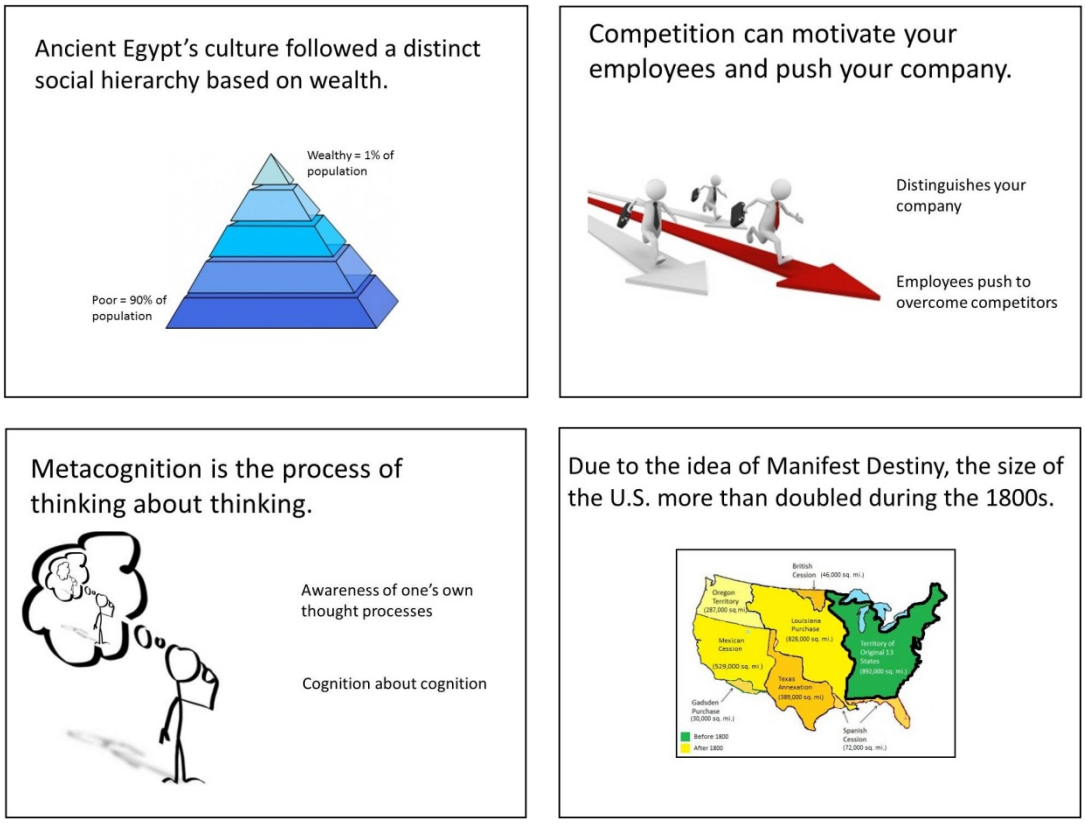

Fig. 10

The results of Phase I seem to predict conceptual images' better performance. For every subject, conceptual images had the highest average score for the question "How informative is this image?" Additionally, participants on the survey often indicated that the slide's point was reinforced by the image. For example, they said:

> The pyramid stresses an obvious metaphor for the class system, which aids comprehension.
>
> The racing figures clearly gets the point across with a memorable scene.
>
> The thinking stick figure makes it really obvious, pictorially, that he's thinking about himself thinking, which is what the information on the slide conveys.
>
> The map is the most informative because it gives a visual representation of the territory expansion.

These comments and the high informational score for conceptual images both seem to show that Phase I participants accurately predicted the conceptual images' strong performance in Phase II.

Summary

This study's results seem to suggest several trends in PowerPoint images. First, SmartArt diagrams appear to backfire easily when they are complicated or contradict any part of the verbal presentation. In these cases, it appears to be more effective to use text-only slides. This corroborates the advice from Levasseur and Sawyer, Sloboda, Alley et al, and Berk, who all warn that poorly selected images can backfire. It also seems to imply that SmartArt is not the same type of image as the cause and effect diagrams that are deemed relevant and effective in science disciplines. Further, it seems to imply that these diagrams are not the helpful visual analogies backed by researchers such as Levie. Second, decorative images seem to be harmless unless they contradict the slide's main idea. This further supports the claims of Alley et al. and other experts, but also backs research by Harp and Mayer, Mayer, and Tangen et al. that showed that relevant images help audience retention better than irrelevant ones. Both of these findings lend support to the research of Mackiewicz, which suggested that image selection is difficult.

Third, conceptual images seem as if they never hurt performance, and often help performance. This appears to suggest that they are the closest some humanities subjects can come to the process diagrams and cause and effect images that Harp and Mayer and Tangen et al. deem most helpful in science subjects. Lastly, text-only slides performed surprisingly well, which seems to indicate that they should be used instead of images that might contradict the slide's main idea. This last finding might be the most surprising, considering the overwhelming literature that suggests that images are helpful to learning (Levin et al; Peeck; Issa et al; Lewalter); however, it also supports the finding from Tangen et al. that suggested that text-only slides perform better than image-irrelevant slides (Tangen et al. 870).

Based on these findings, I recommend a user test for presenters to help them determine which images, if any, to include on their slides. This user test is quick, simple, and could help presenters avoid using images that could backfire. It is described in detail in "Recommendation: User Testing."

Future Directions for Research

Based on the results of this study, there is much more research that needs to be conducted on PowerPoint visuals in the humanities. For the most part, this study's findings are not statistically significant; therefore, a study with a larger sample size would be needed to determine how consistent these results are. Similarly, this study was conducted with only CMU students. A larger study could pull participants from a larger range of institutions and therefore have more generalizable results.

More personally, as a first-time researcher, there were many aspects of the study that I would change or improve in hindsight. In terms of the study design, I chose a range of unrelated subjects that were potentially too simple to understand, even without seeing the presentation. The competition slides, for instance, were intuitive and participants from nearly all image types performed extremely well. Even with the extra padding slides, the presentation itself was also fairly short, so it was not difficult for participants to remain motivated and pay attention. Participants were tested only minutes after viewing the presentation, which does not reflect a real classroom scenario.

Future research could use longer presentations to better mimic class lectures. This would be a better test of participants' willingness to pay attention to the slides. With these longer presentations, it would be interesting to see if the text-only slides still perform better, since Phase I of this study did not test how motivating the text-only slides are. Lastly, the longer lecture would be most effective if it used content that was unfamiliar to the audience. In this study, it is possible that participants already knew the answers to some questions before viewing the presentation. Overall, future research that uses longer presentations and unfamiliar content would better illuminate how text-only slides affect retention compared to SmartArt and other images. Participants could also be tested after a longer span of time, again to mimic a real class lecture.

Recommendation: Usability Testing

As the study results seem to suggest, it is very easy for decorative images and SmartArt to accidentally backfire and hurt audience retention. Therefore, I recommend that presenters user test their images before adding them to slides. From the comments and results from Phase I, we can see that participants made fairly accurate predictions of slide performance in Phase II. Similarly, asking a user to evaluate the image beforehand could save one's audience from a confusing visual.

The user testing process would be quick and simple. Presenters should prepare their images in a separate PowerPoint slide deck. One slide should only show the image, and the other should show the image with the intended heading. Presenters should then recruit a conveniently available participant and first show the image-only slide, asking the participant to predict the heading by interpreting the image. Then the presenter can show the heading and image slide and ask how it matches or does not match the participant's initial impression. If his or her prediction was correct or nearly correct, the image is probably safe to use. Otherwise, if the prediction was very inaccurate or contradictory, it would be better to use a text-only slide. This process could be repeated as many times as the presenter felt necessary, using new participants each time. Figure 11 shows this study design.

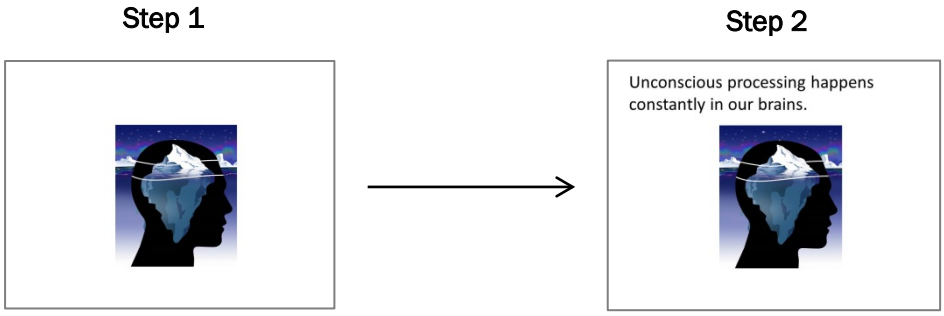

Fig. 11

I informally tried this usability test with a new set of images. These slides are shown in Figure 12. My participants were a CMU student who had never seen the slides before and my project advisor, who had also never seen the slides before.

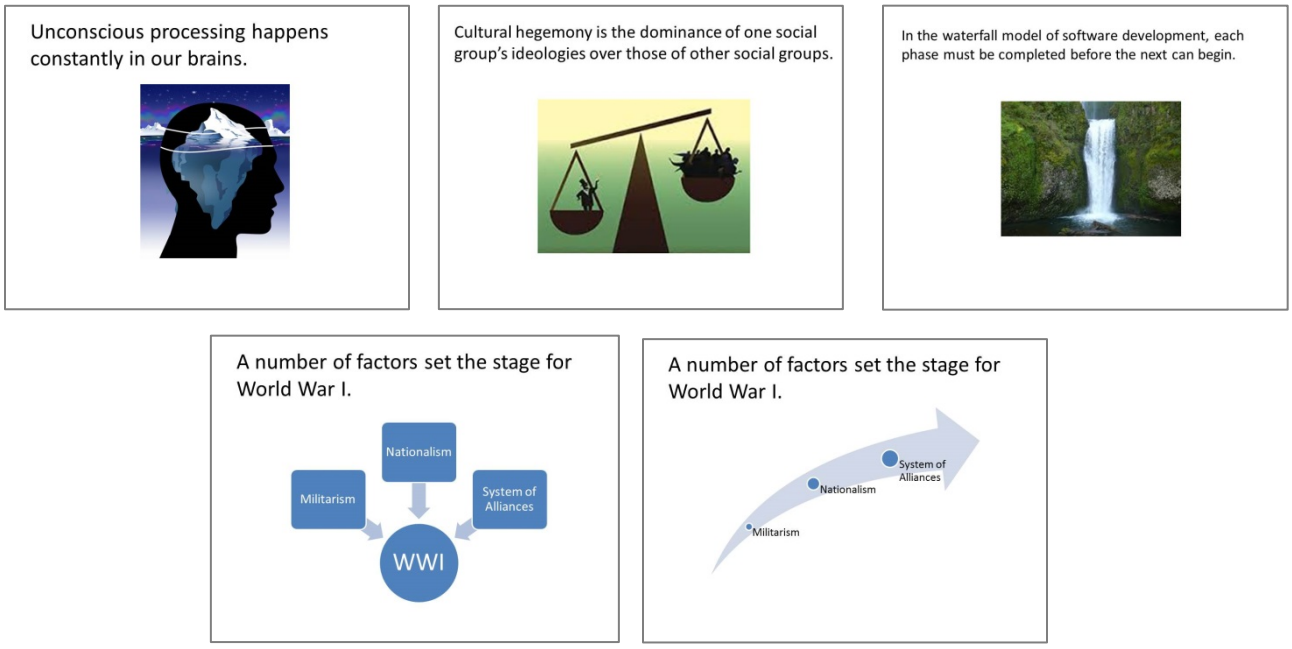

Fig. 12

One slide's subject was psychology, which focused on unconscious processing. I predicted this slide would be conceptual and therefore informative. For this image, one participant understood and the other initially had a contradicting interpretation, saying that it showed that "we don't use the full potential of our brain." This actually contradicts what the slide says, which is that "unconscious processing happens constantly in our brains." Even when shown the heading, the participant did not realize the

contradiction; this is potentially very dangerous because he might never correct this initially false interpretation. As a result, I would not recommend using that image with that slide.

Another slide was about philosophy, specifically cultural hegemony. Similar to the last image, I also thought that this would be conceptual and informative. Both participants understood the cultural hegemony image without seeing the heading, though only one saw the detail that indicated that the lone figure is wealthy. Still, I would say that the image is appropriate and safe to use on that slide.

Next was a slide on software development, specifically the waterfall model. I predicted this would be a harmless decorative image. When tested, neither participant could really interpret the waterfall as having anything to do with software engineering. One initially saw it as "nature" or "serenity," which contradicts the actual meaning. After seeing the heading, however, it was very easy for her to revise her thinking. Contrast this to the confusing conceptual image, where the participant may not have corrected his thinking even after seeing the heading. With this in mind, I would say that the image does not help retention, but also does not backfire. It is safe to use, though there are likely better images to use instead.

The last subject was world history and focused on World War II. For this I tried to create an accurate SmartArt diagram that would perform well, and a backfiring SmartArt that would confuse participants. Both participants correctly interpreted the accurate SmartArt. It therefore seems like a strong visual and I would recommend using it with the slide. On the other hand, both participants saw the backfiring SmartArt and immediately noted some visual contradictions. One noted that the large arrow implied one factor leading to the other, which is not the case, and one noted that the last factor appears larger and more important than the other, which is also inaccurate. As a result, I would not use this SmartArt with the slide for fear of contradicting the heading and confusing viewers.

Overall, the user testing provided some important insights into the new images. Even with only two participants and a very informal procedure, it yielded helpful results that could guide a presenter in her slide design. I would highly recommend such a user test for any presenter who is trying to use decorative images or potentially complex visuals.

Acknowledgments

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This research used human subjects and gained necessary approval through the CMU Institutional Review Board (STUDY2015_00000091).

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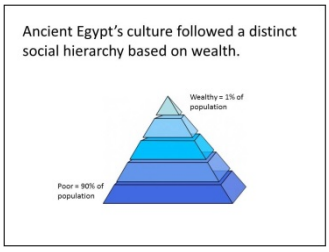
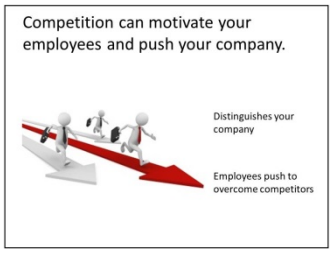
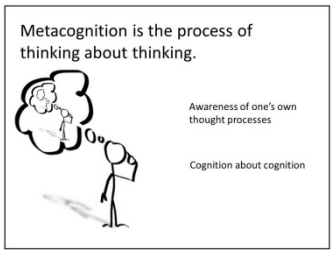
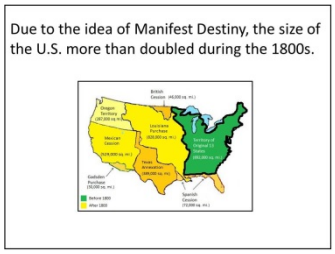
Appendix A: All Slides from Phase II

Conceptual

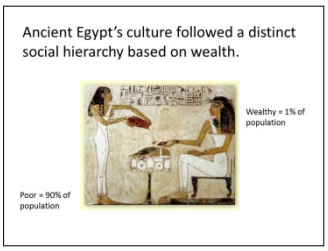


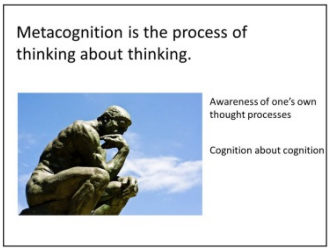


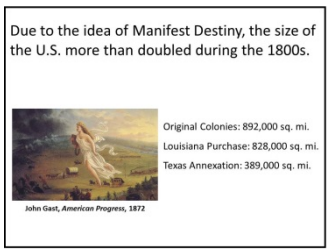




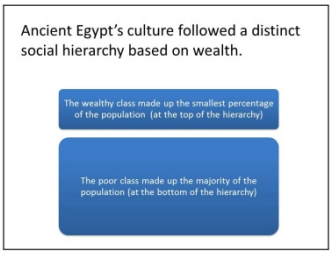
Decorative

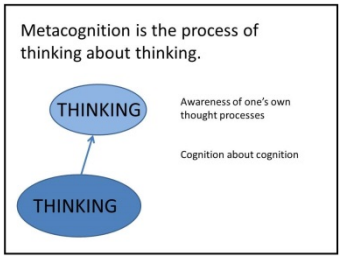


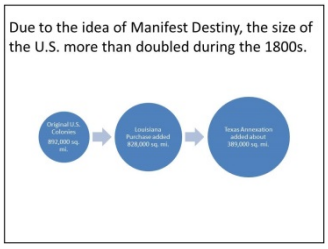




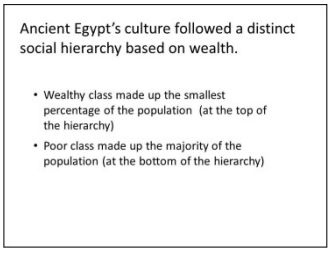
SmartArt

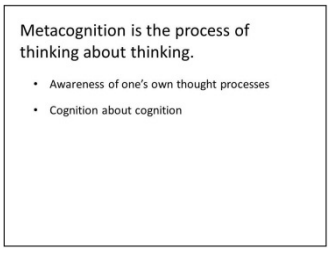


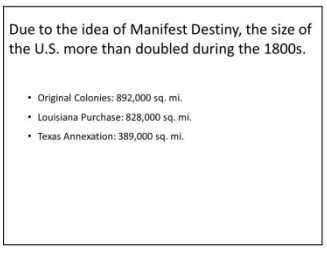




Text-only







Appendix B: Extra Slides Included in Presentation, but not Tested

An omnivore derives its energy from a variety of food sources.

- Berries
- Grasses
- Deer
- Elk
- Fish
- Insects

An elliptical clause is a clause in which some words have been left out.

Jessica had five dollars; Monica, three.

had dollars

An adverbial phrase modifies a verb, adjective, or adverb.

I'll take out the trash in a year.

The Battle of Gettysburg is often considered the turning point of the Civil War.

The Battle of Gettysburg, by Thure de Thulstrup

Appendix C: Retention Quiz from Phase II

Q1 Which participant group are you in?

- ❍ A (1)
- ❍ B (2)
- ❍ C (3)
- ❍ D (4)

Q23 Please answer the following questions based on the presentation you just viewed.

Q2 What was ancient Egypt's social structure based on?

Q3 Which profession belongs in the middle classes of ancient Egypt?

- ❍ priest (1)
- ❍ soldier (2)
- ❍ basket weaver (3)
- ❍ farmer (4)

Q5 Approximately what percent of ancient Egypt's population was considered poor?

- ❍ 80% (1)
- ❍ 99% (2)
- ❍ 95% (3)
- ❍ 90% (4)

Q4 In ancient Egypt, social mobility was possible and most commonly achieved through:

- ❍ learning trades (1)
- ❍ working hard (2)
- ❍ marriage (3)
- ❍ becoming a soldier (4)

Q6 In business, competition can _____ your employees.

Q7 Why could competition be good for your company?

- ❍ It means lower prices for your customers (1)
- ❍ It pushes you to innovate in order to stand out from similar companies (2)
- ❍ You get to interact with customers more directly (3)
- ❍ You can copy ideas from similar competitors (4)

Q8 Competition could force your company to _____ more carefully.

- ❍ File taxes (1)
- ❍ Target customers (2)
- ❍ Evaluate your top executives (3)
- ❍ Manage debt (4)

Q9 Why could competition lead to better employee performance?

- ❍ You will make more money and pay them better (1)
- ❍ Competition will discourage complacency (2)
- ❍ They will have more time to complete their work (3)

Q10 Metacognition is the process of thinking about _____.

Q11 Metacognitive practices can help students _____.

- ❍ Overcome shyness (1)
- ❍ Pay attention in class (2)
- ❍ Attend class on time (3)
- ❍ Adapt their learning to new subjects (4)

Q12 What was the name of the researcher who suggested reflective journaling after an exam?

- ❍ M.D. Gall (1)
- ❍ Kimberly Tanner (2)
- ❍ Susan Turner (3)
- ❍ Mary Tierney (4)

Q13 "Learning how to _____ cannot be left to students. It must be _____."

- learn, taught (1)
- think, learned (2)
- understand, taught (3)
- learn, exemplified (4)

Q14 Because of the idea of _____, the size of the U.S. more than _____ during the 1800s.

Q15 Rank the following territories from largest to smallest (top=largest, bottom=smallest).

_____ Texas Annexation (1)
_____ Original 13 colonies (2)
_____ Louisiana Purchase (3)

Q16 Manifest Destiny was the idea that the U.S. was destined to do what?

- Stretch from coast to coast (1)
- Reclaim land from the British (2)
- Defeat Mexico (3)
- Take control of Texas (4)

Q17 Westward expansion led to conflict with whom?

- Native Americans (1)
- France (2)
- Mexico (3)
- Both A and B (4)
- Both A and C (5)

Q21 Are you a U.S. citizen?

- Yes (1)
- No (2)

Answer If Are you a U.S. citizen? No Is Selected

Q22 What country are you a citizen of?

Q19 What is your gender?

- ❍ Female (1)
- ❍ Male (2)

Q21 What year are you?

- ❍ Freshman (1)
- ❍ Sophomore (2)
- ❍ Junior (3)
- ❍ Senior (4)
- ❍ Fifth year (5)
- ❍ Graduate (6)

Q23 Which of the following categories best describes your primary major?

- ❍ Engineering (1)
- ❍ Social sciences (2)
- ❍ Humanites (3)
- ❍ Arts (4)
- ❍ Natural sciences (5)
- ❍ Computer science (6)
- ❍ Other (7) _____

Appendix D: Phase II Presentation Audio Script

Parenthesis indicate that participants were not tested on that slide.

Egypt

Ancient Egypt's culture followed a distinct social hierarchy based on wealth. The wealthy class made up the top 1 percent of the population. This mostly made up of nobles and priests. The poor class made up 90 percent of the population. This included slaves and farmers. The other 9 percent in the middle included soldiers, skilled workers, and merchants. Social mobility was possible if you had your children learn trades or if they learned to read and write because they could then become a scribe.

(Omnivores)

An omnivore derives its energy from a variety of food sources. In Latin, omnivore means "all-eater," which makes sense because omnivores eat things like plants, animals, algae, fungi, and bacteria. Many bears are omnivores, including the grizzly bear shown in the picture, who eats berries, grasses, deer, elk, fish, and insects. Other examples are sloths, squirrels, and of course humans.

Competition

Competition can motivate your employees and push your company. Employees are less complacent and comfortable when they feel that they're competing with another company. It will also force your company to compete for customers, and could lead to better customer service. Competition pushes you to innovate in order to distinguish yourself from other similar companies. It will also force you target your market more carefully. For example, you might pay attention to a specific demographic. You can also see what doesn't work for other companies.

(Adverbial phrase)

An adverbial phrase modifies a verb, adjective, or adverb. Like adverbs, they'll tell us when, where, or how something happens. In the example, the adverbial phrase is "in a year," which tells us when the verb, "take out," will happen. Notice that the phrase doesn't contain an adverb but still functions adverbially.

Metacognition

Metacognition is the process of thinking about thinking. More specifically, it refers to processes we use to plan, monitor, and assess our own understanding. In education, metacognitive practices can help students adapt their learning to new contexts. It gives them an awareness of what learning strategies work for them. For example, one researcher, Kimberly Tanner, recommends that students write in reflective journals after an exam to write down which study strategies worked for them, and which didn't work. One quote that is often heard in metacognitive education comes from M.D. Gall, who said, "learning how to learn cannot be left to students. It must be taught."

(Elliptical clause)

An elliptical clause is a clause in which some words have been left out. Because of the pattern or logic of the entire sentence, it is clear what the missing words are. The example sentence says, “Jessica had five dollars; Monica, three.” Even though “had” and “dollar” were taken out, we still understand that Monica had three dollars. This avoids unnecessary repetition. In this case, there’s a comma to indicate the missing word, although this isn’t always true.

Manifest Destiny

Due to the idea of Manifest Destiny, the size of the U.S. more than doubled during the 1800s. This was the idea that the U.S. not only could, but was destined to reach from coast to coast. This fueled huge westward expansion, and therefore Native American removal and war with Mexico. The original U.S. colonies were 892,000 square miles. Just the Louisiana Purchase alone added 828,000 square miles. This almost doubled the size already. Later, another big acquisition, the Texas Annexation, added 389,000 square miles. Other acquisitions included the Oregon Territory, the British Cession, the Mexican Cession, the Gadsden Purchase, and the Spanish Cession.

(Battle of Gettysburg)

The Battle of Gettysburg is often considered the turning point of the Civil War. It took place on July 1st through 3rd in 1863 in and around the town of Gettysburg, Pennsylvania. The battle involved the largest number of casualties of the entire war. Union General George Mead defeated attacks by Confederate General Robert E. Lee, ending Lee’s invasion of the north.