VIOLATING EXPECTATIONS IN VISUALIZATIONS: EFFECTS ON PERCEPTION, RECALL, AND DECISION MAKING IN A COURTROOM SETTING

A Thesis
Presented
to the Faculty of
California State University, Chico

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Interdisciplinary Studies:
International Cognitive Visualization

by
Simone Lanette Simpson
Summer 2013
VIOLATING EXPECTATIONS IN VISUALIZATIONS: EFFECTS ON PERCEPTION, RECALL, AND DECISION MAKING IN A COURTROOM SETTING

A Thesis

by

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Summer 2013

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ABSTRACT

VIOLATING EXPECTATIONS IN VISUALIZATIONS: EFFECT ON RECALL AND DECISION MAKING IN A COURTROOM SETTING

by

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Master of Arts in Interdisciplinary Studies

International Cognitive Visualization

California State University, Chico

Summer 2013

In this study we examined how a visual violation of expectations could affect recall of expectancy-violating materials and influence decision making from these materials in a courtroom setting. One hundred and two undergraduate students were asked to assume the role of a jury member and learn about a case. Then, participants were exposed to a bar graph representation of a major case argument that either did not violate their expectations (static presentation), violated their expectations (static-sequential presentation), or double violated their expectations (animated presentation). Results revealed no differences on recall between all three conditions. However, participants in the animated condition awarded more money to the plaintiff for pain and suffering than participants in the static-sequential condition, and were also more confident in their decisions of guilt than the static condition. Therefore, violating visual expectations may not have an effect on direct recall of material, but it could have an emotional influence on
decision making. More research is needed to understand how and why this effect occurs, and if this effect persists in other visualization settings.
CHAPTER I

INTRODUCTION

Background

Research on visualizations has provided many different principles and guidelines for visualization construction (Mayer, 2001; Moreno, 2006; Kossyln, 2008). In addition, visualization research has facilitated the development of theories and exploratory models of how visualizations can influence learning (Schnott, 2003; Schnott & Bannert, 2005; Schnott & Kurschner, 2008; Mayer, 1997; Mayer, 2001; Mayer 2002; Mayer 2003). However, these principles and theories have a very strong foundation in instructional research (Tversky et al., 2002). Consequently, it is difficult to generalize the results of these instructional studies to fields outside of instruction.

For example, it is problematic to generalize these instructional results to the field of litigation. Although juries in a court of law are asked to learn courtroom material, they must learn this material in a litigation setting. In addition, the most important consequence of visualization learning in litigation is the resulting decisions that are made by jury members. This is contrary to the accuracy and transfer task outcome measures that are often a focal point in instructional visualization research (Hegarty, 2011). Therefore, in order to understand the effects of visualizations in litigation, it is imperative to conduct visualization research within the actual field of litigation.

Currently, research has been conducted on visualizations in the courtroom, but this research has been very limited (Feigenson, 2010). Of the existing litigation
visualization research, findings have also been very mixed. In addition, a major focus of this research has been on emotionally provoking visualizations in order to analyze what types of visualizations can be allowed in the courtroom (Feigenson, 2010). Little focus has been allocated to studying visualizations that could serve as cognitive aids in the courtroom (Feigenson, 2010).

Outside of the courtroom, visualizations have been shown to facilitate cognitive processing (Mayer, 2002). In addition, it has been shown that coupling visualizations with relevant auditory presentations of information can promote learning of material (Mayer, 2002). Therefore, pairing visualizations with traditional courtroom auditory arguments of the plaintiff and defendant could positively influence a jury’s understanding of a case. Research shows that when jurors can understand a case, they are more likely to produce stronger verdicts (Pennington & Hastie, 1992). Consequently, influencing jurors’ cognitive processing could result in stronger juror decision making.

However, not all visualizations are beneficial to cognitive processing (Mayer, 2002). Efficient visualizations are entirely contingent on visualization properties and task demands (Hegarty, 2011). Thus, simply introducing visualizations into a courtroom will not inherently increase a jury’s understanding of a case. Therefore, it is important to shift previous visualization research to focus on specific litigation scenarios with particular visualization task demands.

Our research specifically focuses on contributing to static and animated visualization research in a courtroom setting. However, we were not simply interested in varying the type of representation. We were mainly interested in how a visual violation of expectations could be facilitated with these representations. With this visual expectancy
violation, we were interested in how cognitive processing could be affected which could in turn influence decision making from these materials. We contend that violating jurors expectations could be a way in which lawyers often choose to present their arguments. However, to our knowledge, no research has been conducted on violating expectations with visualizations. Let alone violating visual expectations in litigation. Consequently, our aim was to study how a visual violation of expectations could affect juror’s recall and decision making in the courtroom.

Violating Expectations Research

A violation of expectations has been consistently defined across several other areas of research; such as, infant development, reading comprehension, and auditory attentional capture (Wang et al., 2004; Camras et al., 2002; Parmentier et al., 2010; Baker & Anderson, 1982; Vachon et al., 2011). A violation of expectations is specifically defined as any event that occurs that is inconsistent with what an individual believes or predicts should theoretically occur. Across several fields, a violation of expectations has been shown to increase attention (Wang et al., 2004; Camras et al., 2002; Parmentier et al., 2010; Baker & Anderson, 1982; Vachon et al., 2011).

In particular, research has shown that it is not merely novelty in a violation of expectations that captures attention (Wang et al., 2004; Vachon et al., 2011; Parmentier et al., 2010). Infants that are not habituated to study materials will still look significantly longer at expectancy-violating events. Therefore, even when all materials are novel to an infant, a violation still serves as the most fundamental form of attentional capture (Wang et al., 2004).
Furthermore, adults that were presented with predictable novel auditory sounds were found to become habituated to these novel sounds over time (Vachon et al., 2011). These participants displayed less distracted behaviors when prediction of an auditory stimulus could be made. However, participants that were presented with auditory sounds that consistently violated their expectations displayed a continuous level of distraction or attentional capture (Vachon et al., 2011). Therefore, auditory attentional capture persisted with violating sounds, but allocated attention decreased if the sounds could be accurately predicted.

In addition, Parmentier and colleagues (2010) found that a violation of expectations also had to be directly related to a task. Therefore, a violation of expectations occurs when task relevant material is introduced that is not simply novel, but that violates a prediction of what should occur.

A violation of expectations has also been shown to increase attentional capture regardless of culture (Camras et al., 2002). Therefore, a violation of expectations could have an inherent, and not learned effect, on processing. Yet, this phenomenon does not provide evidence for how this increase in attention affects cognitive processing.

Olson and colleagues (1981) provide a prediction model of text that particularly explains how a violation of expectations could influence attentional capture. In this model, attention is described as being directed and focused while reading. Therefore, appropriate schemas are activated and predictions are created for incoming text in an attempt to facilitate reading comprehension. Thus, if a violation of incoming text occurs, an individual would have to shift their attention to re-access relevant information in long-term memory while re-formulating their cognitions about the text.
Therefore, an increase in attention would occur with a text that violates expectations as individuals would need to re-structure their cognitive processing. However, this theory, as well as relevant research, heavily focuses on the presence of increased attention with violations of expectations. Yet, we contend that it is also important to examine the resulting effects of this increase in attention.

For example, it would be beneficial to understand how comprehension is affected, or how this increase in attention could affect recall of expectancy-violating material. It is also not understood in expectancy violating research why this increase in attention occurs. For instance, do individuals need more cognitive resources to process a violation of expectations, and thus need more time, or do individuals feel a surprise effect and take longer to process this surprise? In addition, how could this possible surprise effect affect decision making? Could it increase strength of decisions?

Interestingly, individuals that are notified that they will experience expectancy-violating events still devote more attention to material that violates their expectations (Baker & Anderson, 1982). Therefore, it is possible that a violation of expectations is so strong that it remains surprising and captivating even with prior knowledge of a violation. Or, it could be that a violation of expectations actually induces a delay in processing. Thus, examining recall accuracy would provide a construct to understand if processing is facilitated or hindered with a violation of expectations. Then, examining resulting decision making would provide a construct of how these processing effects could influence final decisions.

Inducing a visual violation of expectations could be facilitated by delaying the reveal of subsequent information. In this way, individuals could develop predictions or
expectations of materials that are necessary for a violation of expectations to occur. One possible method to delay the presentation of subsequent information would be to present information sequentially or to present information in an animated fashion. Therefore, a static presentation that inherently reveals all information at once would not induce a visual violation of expectations. Consequently, it is important to understand the visualization consequences of using static versus static-sequential and animated displays while exploring the effects of these different levels of visual violations of expectations.

Static versus Animated Visualization Research

Numerous studies have been conducted on static, static-sequential, and animated visual representations (Tversky et al., 2002). However, results of these studies have provided mixed and contradictory findings. Three issues might contribute to the inconsistency in static versus animated visualization learning outcomes (Tversky et al., 2002). First, the degree of content between animations and static representations in these studies often differ. Animations often provide more content than the static images that they are compared against. This content differentiation does not allow for accurate comparisons. Second, animations are often combined with interactivity which introduces a possible confounding influence. Third, animation research is often too heavily focused on complex animations which does not allow for a clear understanding of animations themselves (Tversky et al., 2002). Therefore, future research should control for these confounds by studying simple animations, without interactivity, that display the same content as their static counterparts.
Regardless of these constraints, animations have been found to be more beneficial than static representations for representational graphics (Höffler & Leutner, 2007). In addition, animations have been found to be as beneficial as or even better than static representations when information is not removed throughout the presence of the animation (Höffler & Leutner, 2007; Boucheix & Schneider, 2009; Imhoff et al., 2012). Although, if static material is presented sequentially, in an integrated fashion, positive results on cognition have been found to be similar to animated materials (Boucheix & Schneider, 2009). Static sequential material that is removed as new material appears does not facilitate learning as positively as integrated static-sequential material or animated material (Boucheix & Schneider, 2009; Imhoff et al., 2012). Therefore, an important factor in the success of animations and static-sequential presentations is the continual presence of all incoming materials.

Conversely, Imhoff and colleagues (2012) found that purely static material can score as high as animated material, but that this result is dependent on the format of the material. For example, animated materials have been shown to facilitate learning more than static materials when material is presented in columns (Imhoff et al., 2012). Therefore, spatiality of displays can influence when animations can be more beneficial than static displays. Thus, we must conduct research in several spatial formats in order to understand how animations and static representations behave under certain scenarios.

Furthermore, the speed of animations has been found to have no effect on learning outcomes (de Koning, 2011). Animations that are presented at either high or low speeds have not demonstrated any different effects on learning. Therefore, it is not the
presentation rate of material, but rather the sequence of material that could influence learning.

Consequently, success of animations is dependent on the format of the material as well as ensuring that no information is removed in the animation process, regardless of the speed. In addition, static-sequential material that is integrated together can have similar effects to animations. Thus, design of animations should strongly incorporate the results of this previous research. Furthermore, design of animated versus static research should address the three confounding variables of differing content, interactivity, and complexity that are found in current research.

However, it is also important to examine how animations and static-sequential presentations can be more beneficial than their static counterparts. We argue that information in animations and static-sequential presentations are inherently cued. Cueing has been found to direct attention (Amadieu et al, 2011). When attention is guided, comprehension and learning can be facilitated by directing the learner to relevant information necessary for learning (Amadieu et al, 2011). Therefore, static-sequential and animated presentations could serve as attention guides to incoming material which could positively influence learning. De Koning and colleagues (2010) conducted an eye-tracking experiment to examine the effects of explicitly cued versus implicitly cued animated material. Results indicated that participants looked significantly longer at explicitly cued information. However, there were no performance differences between groups. Therefore, animations and static-sequential presentations could have the same benefits of explicitly cued material, simply due to their implicit cueing nature. Thus, animated and static-sequential material could positively influence recall.
Jury Decision Making Research

Recall accuracy of case materials is something that the jury system relies on. Jury members are not tested on their recall accuracy of a case. Instead, it is implied that they will remember information accurately, and make sound decisions. The most important result of a jury is their final verdict about the case. However, several factors can influence jury decision making (Devine et al., 2000). Story construction theory provides a model of how jury members make decisions (Pennington & Hastie, 1986, 1988). In this model, jury members individually construct a coherent mental representation of case materials. The more jury members are capable of constructing a coherent mental representation, the stronger their decisions of guilt or innocence become, as well as their confidence in those decisions (Pennington & Hastie, 1992). Therefore, enabling story construction should be highly valued while presenting case materials.

However, it is important to note that hindsight bias could alter the types of stories that jurors create (Casper et al., 1989). When jurors are presented with outcome information of a case, it has been shown that it is difficult for jurors to ignore this information. Therefore, knowing the results of a company’s actions could influence a juror’s perceptions of the initial actions of the company. Thus, the hindsight bias of “knowing the company was guilty all along” could retrospectively occur (Casper et al., 1989). For example, jurors who were presented with different outcomes of a police search altered their decisions of damage awards. So, even though the behavior of the police officer, before knowing if the search was successful or not, was on trial, outcome information had an effect. Therefore, presenting jurors with outcome information could inherently bias decisions of guilt due to the hindsight bias effect. In this study, outcome
information either violates or does not violate expectations about what the outcome should be. Therefore, we are interested in how a violation could increase this hindsight effect and influence guilt and damage awards.

The Present Investigation

In the present investigation, we asked participants to assume the role of jury members in a real courtroom case. Participants were asked to read a case background on a medical product liability case and to study a graphic visualizing the main argument of the case. One third of participants were presented with a static graphic, one third were presented with an integrated static-sequential graphic, and the remaining third were presented with an animated graphic of the same material. The graphic consisted of a bar graph that, when presented over time, induced a violation of expectations. Therefore, no violation was present in the static condition. We then asked participants to recall the bar graph in order to examine if a violation of expectations could increase recall accuracy due to proposed attentional capture. Finally, we asked participants to make decisions about the guilt and damage awards they felt should be attributed to the medical company that produced the product.

The medical product liability case involved an artificial hip that was placed on the market by a company. The company was not required to conduct medical testing before placing the product on the market. Instead, the company was required to monitor the product’s success by closely observing the revision rate of the product. The revision rate was the amount of times that the product resulted in complications in patients and had to be removed and replaced. This removal and replacement surgery, or revision, has
been known to sometimes create severe consequences for patients. Across three years of revision rate data, where the product’s revision rates were higher than other similar products on the market, the company did not recall the product. Participants were told that the company recalled the product after four years. However, at year three, the amount of product revisions was eight times higher than what would be expected from the revision rate data at year one and year two.

Consequently, when revision rate data was presented sequentially across years, a prediction for year three could be established from the amount of change that occurs between year one and year two. Therefore, when year three was presented, a violation of expectations occurred, because the height was not what would be predicted (Wang et al., 2004; Vachon et al., 2011; Parmentier et al., 2010; Baker & Anderson, 1982). Thus, the static-sequential and animated conditions contained an expectancy violation. However, we argue that participants in the animated condition developed stronger predictions than in the static-sequential condition. In the animated condition, the expected height of the product bar at year three was violated, but the expected growth of the bar was also violated. Therefore, two expectancy violations occurred in the animated condition. We reason that participants in the static condition did not experience a violation of expectations for the product bar at year three because these participants did not have the time to create a prediction from year one and two to year three.

Due to previous violation of expectations research, we hypothesized that participants in the animated and static-sequential conditions would devote more attention to the product bar at year three than the static condition. We also hypothesized that the animated condition would foster the highest amount of attention between all three groups.
With the expectancy-violating attentional capture effect, we hypothesized that participants would be more accurate at recalling the product bar at year three. However, due to the final expectancy-violation outcome, we hypothesized that the higher the amount of expectancy-violation, the less accurate recall of the entire graph would be. Specifically, we hypothesized that the product bar would be recalled significantly higher across year one and year two. Therefore, that the influence of the violation of expectations would reformulate the initial mental representation of material and be influenced by hindsight bias that the product bar must have always been higher (Casper et al., 1989).

We hypothesized that recall of the graph would influence participant’s decisions about the case. If participants recalled the graph differently, it is possible that participants perceived the graphs differently. Therefore, that participants developed different coherent mental representations, or stories, of the case (Pennington & Hastie, 1988, 1986). Variations of story construction have been shown to influence decisions of guilt and damage awards (Pennington & Hastie, 1992). Therefore, we hypothesized that if participants recalled the graphs to be higher than the actual graph in the animated and static-sequential condition, that these participants would make stronger decisions of guilt, with higher confidence, and would attribute higher damage awards to the injured party.

In order to avoid any possible confounds found in previous animated versus static research, we carefully constructed our graphic to address aforementioned issues. We ensured that all content remained equal between conditions, and that no additional information was provided by viewing an animated representation. Animated and static-sequential graphs were not interactive, and revealed incoming pieces of the graph at
consistent time intervals. We also developed a very simple two variable black and white bar graph in order to avoid adding any confounds of animation complexity to our design. In addition, we did not remove any material once it was presented, in order to prevent any negative effects on working memory.

By avoiding confounds of comparing animations to static materials, we hypothesized that we could accurately examine any violation of expectations effects. We induced a visual violation of expectations by varying the representation type of a bar graph. We hypothesized that an animated bar graph would invoke the strongest violation of expectations, and consequently have the strongest influence on recall and decision making. Second, we hypothesized that a static-sequential bar graph would invoke a violation of expectations effect, but that the resulting influence on recall and decision making would not be as strong as in the animated condition. Third, we hypothesized that a static bar graph would not invoke a violation of expectations and would have the least amount of influence on recall and decision making.

We believe that this research will contribute to existing litigation law research as well as contribute to existing animated versus static research. When violations of expectations can be presented in a court of law, it would be beneficial to understand how these violations can ultimately influence jury members. In addition, it is beneficial to animated and static research to understand how a violation of expectations could influence recall accuracy between static and animated graphics. Thus, understanding that a violation of expectations that is capable of being induced by animated or static-sequential visualizations, could affect resulting cognitive processing. Therefore, in scenarios when a violation of expectations can occur, representation type should not be
classified simply in terms of animated versus static representation. Instead, this violation
could guide visualization processing.
CHAPTER II

LITERATURE REVIEW

Introduction

Violating expectations has been shown to have attentional effects at a very early age (Wang et al., 2004). Inducing a violation of expectations is a common method to test young infants’ abilities to mentally represent hidden objects. This particular method was first employed by Baillargeon and colleagues in 1985 in order to demonstrate infant’s earlier development of object permanence. In the violation of expectations method, an infant is habituated to a set of materials before being presented with two test trials. One test trial presents an event to the infant that is consistent with what should theoretically occur, and therefore should not violate the infant’s expectations. Another test trial presents an event that is inconsistent with what should theoretically occur, and therefore should violate the infant’s expectations. Thus, a violation of expectations is specifically defined as any event that violates an individual’s expectations of what should occur. Results from these experiments have shown that when infants can mentally represent objects, infants will actually look significantly longer at events when a violation of expectations occurs. Therefore, it is reasoned that this increase of attention is due to a surprise effect that is induced by witnessing an event that violates expectations (Wang et al., 2004).

Camras and colleagues (2002) explored this attentional phenomenon cross-culturally. Across European-American, Japanese, and Chinese infants, all infants devoted
significantly more attention to events that violated expectations. However, there were noted behavioral differences across cultures. American and Japanese infants showed more behaviors of stilling their bodies, and American infants displayed more sobering facial expressions. However, regardless of some behavioral differences, a violation of expectations was shown to increase attention across all cultures (Camras et al., 2002).

However, criticisms about the violation of expectations method questioned whether infants were actually surprised by the violation of expectations, or if the increase in attention was simply due to the novelty of the material presented in the violating event (Wang et al., 2004). In order to demonstrate that this was not the case, Wang and colleagues (2004) conducted two studies without the traditional habituation period of violation of expectations studies. Results of these studies still produced the same attentional capture in infants with a violation of expectations. Therefore, a violation of expectations was significantly correlated to heightened levels of attention. However, it is difficult to infer with infants any underlying cognitive effects. Thus, it is important to study how a violation of expectations cognitively and behaviorally affects adults.

**Violating Expectations**

In order to understand how a violation of expectations could cognitively and perceptually affect adults, we will review several studies surrounding the topic of expectancy-violations across different mediums.

**Violation of Expectations in Reading**

Baker and Anderson (1982) directed a text-based violation of expectations study. Before the study began, half of the participants were informed that they would
encounter inconsistencies within their text passages, and half of the participants were not informed of the following inconsistencies. Then, participants were instructed to read the material. Participants were also urged to reread any material that they wished. Results indicated that when a violation of expectation, or inconsistency, occurred in a sentence, both groups spent more time reading the sentence. In addition, participants in both groups re-read sentences that violated expectations more often than sentences that did not violate expectations. Therefore, violations in expectations attracted more attention to expectancy-violating material. Interestingly, this effect still occurred when participants were informed that violations would occur. Therefore, even being prepared for a violation did not change the attention grabbing effects of a violation.

The prediction model of comprehension (Olson et al., 1981) provides an explanation for this phenomenon. This model hypothesizes that when a reader makes predictions about a text, attention is directed and selectively focused on the upcoming text. Consequently, an expectation is created for what should appear in the text. Thus, if the text fulfills a reader’s expectation, comprehension would be facilitated by using the most directed and relevant cognitive resources. However, if the text does not fulfill a reader’s expectation, the reader must reformulate their idea about the text which would thus require more attention.

Duffy (1986) conducted a study regarding high expectation and low expectation provoking texts that provide support to the prediction model. When presented with text that induced high expectations for subsequent sentences, participants took more time to read a sentence that violated their expectations than sentences that did not violate their expectations. Therefore, high expectations influenced the amount of attention
participants placed on expectancy-violating material. In addition, if expectations were low, this effect did not occur.

Violations of Expectations in Auditory Environments

Research on violations of auditory expectations has its roots in novel auditory stimuli studies (Parmentier et al., 2011). These studies initially demonstrated auditory attentional capture effects. Results from these studies showed that participants engaged in various focal tasks, from visual to tactile, were attentionally affected by the introduction of a novel auditory stimulus. When the novel auditory stimulus was introduced, participants took longer to respond to focal tasks and accuracy of participants' responses were sometimes affected. (Parmentier et al., 2011). However, Parmentier and colleagues (2010) hypothesized that it was not just a simple introduction of a novel stimulus, but rather that this stimulus had to violate the expectations of a participant in order to have an attentional effect.

Parmentier and colleagues' (2010) hypothesis was supported by a study examining the introduction of different types of novel stimuli. Results showed that attentional capture by a novel auditory stimulus did not occur if the novel sound did not have any informational value to the task. Therefore, if the change in sound was not related to the task, no attentional capture occurred. Thus, if participants could predict sounds in relation to the task, and a novel unexpected sound occurred, attention was captured. Consequently, Parmentier and colleagues (2010) demonstrated that a prediction of sounds was necessary for attentional capture to occur.

Vachon and colleagues (2011) also conducted a study supporting the idea of expectancy-violations versus simple novelty attentional capture. Participants were asked
to recall visualizations that were presented to them while listening to either novel or expectancy-violating auditory information. In the first study, a violation of expectations occurred when the voice of the narrator was changed after five trials. However, participants were allowed to habituate to the predictable five trial change. In the second study, a violation of expectations occurred more frequently by changing the voice of the auditory material unpredictably. Attentional capture for both studies was defined as distracting a participant during a short term memory task.

Across both studies, no attentional capture was demonstrated when the material was simply novel and first encountered. In study one, evidence of attentional capture was present after a violation of expectations, but the extent of attentional capture decreased across trials as the participants habituated and correctly predicted the change. Therefore, participants were less distracted by the violation over time. Alternatively, in the second study, when correct predictions of voice change could not occur, attentional capture was increased. Therefore, when expectations of the auditory information were violated, attentional capture was increased. Consequently, participants were more distracted by random violation of expectations.

However, it is important to note that materials in these studies were always presented in two channels—auditory and visual, or sometimes auditory and tactile. Most commonly, a violation of expectations occurred within the auditory channel while the ability to concentrate on the visual channel was affected. Dual coding postulates that processing occurs simultaneously for auditory and visual information (Pavio, 2006). However, it can be argued that the violation of expectations was so influential in these studies that it could have heavily allocated attention resources to processing the auditory
information (Pavio, 2006). Thus, leaving little attention and short-term memory resources for the processing of the visual materials. Therefore, if all material was presented in the same channel, it is possible that a capture of attention would be beneficial to processing and would therefore aid in recall and decision making.

Violation of Expectations in Visualizations

During this literature review, no studies were found that explored the concept of violating expectations in visualizations. However, visualizations are increasingly being used and understanding their effects is contingent on the properties of particular visualizations (Hegarty, 2011). Therefore, understanding how a violation of expectations could affect visualization processing would contribute to the growing field of visualization research. Yet, we must first understand how visualizations are processed.

Visualization Processing

The following two theories of multimedia learning are fundamental in the field of visualizations. They have established core ideas of visualization processing and have presented a frame of reference to understand underlying cognitive processes of visualizations. They are beneficial to understand how visualizations influence learning and to understand the importance of effective visualizations.

Mayer’s Cognitive Theory of Multimedia Learning

Mayer’s cognitive theory of multimedia learning (2005) provides a framework for how visualizations are processed. Multimedia learning is defined as learning that occurs when information is presented by both words and pictures (Mayer, 2003). Mayer argues that information can be more accurately processed and understood when
information is presented in both modes, also known as the multimedia effect (Mayer, 1997). However, in order for the multimedia effect to be beneficial, the quality of the visual and verbal materials is highly important (Mayer, 2005). Therefore, the simple addition of visualizations to text does not inherently benefit the learner. In fact, if visualizations are poorly paired with text, they can actually hinder learning (Mayer, 2005). Mayer’s theory (2005) illustrates how multimedia is processed in order to understand how to maximize the benefits of multimedia learning.

The basis of the theory relies on three assumptions of human cognitive processing that information is processed in dual channels, in an active manner, with a limited capacity (Mayer, 2005). The theory of dual channels was created by Pavio (1986). In this theory, information is simultaneously processed in either a visual or verbal channel. In terms of Mayer’s cognitive theory of multimedia learning (CTML), multimedia is presented by pictures or words. Pictures are processed in sensory memory with the eyes. However, the presentation of words can be processed in sensory memory by either the ears or the eyes. If words are spoken, they are processed in sensory memory by the ears. Alternatively, if words are written, they are processed by sensory memory by the eyes. Therefore, in order to maximize the use of both channels, Mayer advises presenting images with narration (Mayer, 2005). This is also known as the modality principle.

The second assumption of CTML pertains to active processing (Mayer, 2002). In order for effective learning to occur, learners must actively engage with learning material. In particular, effective learning occurs when learners actively select relevant information, organize this selected information into coherent mental models, and then
integrate the resulting verbal and pictorial models into one cohesive mental model.

However, this process is highly dependent on prior knowledge and individual differences.

The third assumption of CTML pertains to the limited space of working memory. Baddeley’s (1986) theory of working memory states that there is a limited capacity for information processing between perception and transfer of incoming information to long-term memory. Space in working memory is so limited that working memory can only process seven, plus or minus two, units of information (Miller, 1956). Furthermore, working memory is subdivided into three components: the central executive, phonological loop, and visual-spatial sketchpad (Baddeley, 1986). The central executive guides what information will be attended to, similar to the selective component of Mayer’s model. The phonological loop is similar to the verbal channel where auditory information is processed. The visual-spatial sketchpad is similar to the visual channel where visual information is processed. These three components are also restricted to the capacity limitations of working memory. Therefore, in Mayer’s model, the visual and verbal channels are also constrained by the limitations of working memory. If too much information is presented in one channel, the channel can become overloaded and have no resources to process additional information.

With these assumptions in mind, CTML can be described as a process (Mayer, 2005). First, presented multimedia information enters sensory memory. Pictures and written words are viewed in sensory memory by the eyes, and spoken words are heard in sensory memory by the ears. Then, relevant information is selected by the learner into working memory. From the ears, selected words are transferred into the similar phonological loop of Mayer’s model. From the eyes, selected images are transferred into
the similar visual-spatial sketchpad of Mayer’s model. Information is exchanged between these components and organized. At this point, visual and auditory words are organized into a verbal model and images are organized into a pictorial model. Finally, the verbal and pictorial models are integrated together with influences of learner’s prior knowledge from long term memory (Mayer, 2005).

Schnotz’s Integrated Model of Text and Graphic Processing

Schnotz’s (2002) integrated model of text and graphic processing elaborates on CTML and dual coding theory. Schnotz (2002) argues that it is problematic to think about text and graphic processing in the parallel manner that is found in CTML and dual coding theory. Instead, Schnotz (2002) suggests that a more comprehensive model would incorporate representational principles that take into account the different sign systems that are employed in text and graphics.

Fundamentally, the model distinguishes between internal and external representations (Schnotz & Bannert, 2003). External representations consist of any representation outside of the body and mind. Therefore, text and graphics are considered to be external representations. Internal representations consist of any representation within the mind. Consequently, internal representations are heavily influenced by “prior knowledge, cognitive abilities, and learning skills” (Schnotz, 2002, p. 101). Comprehension of material begins when an individual transfers an external representation into an internal representation. The selection of this material is a highly task-driven process.

However, there are essential distinctions between text and graphic external representations which rely on fundamental symbol and icon sign properties developed by
Pierce (1906). First, text and graphics are made of different signs. Text representations are made of symbols. Symbols have an arbitrary relationship to their referent. Therefore, it is impossible to determine the meaning of a symbol, without the prior knowledge of how the symbol is related to its referent. Thus, text is considered as a symbol because meaning is only derived by convention. Alternatively, graphics are made of icons. Icons have a direct relationship to their referent. Therefore, meaning is not derived from convention and icons can be understood due to their similarity to a referent.

Graphs have both symbol and icon properties. In terms of symbols, graphs are not visually similar to their referent and some of their structural properties are built on convention. However, Schnotz (2002) argues that graphs are actually icons because their structural properties are so similar to their referents. Therefore, Schnotz (2002) argues that the idea of similarity for icons must be thought of in a more broadened sense.

In addition to sign classification, text and graphics are considered to provide different types of representations. Texts provide descriptive representations that describe referents with symbols. Graphics provide depictive representations that portray referents with icons. Although, descriptive and depictive representations are not restricted to external representations of text and graphics. They can also signify types of internal representations that are formed from such external representations.

The process of internal representation formation is described in Schnotz’s (2002) integrated model by utilizing the aforementioned terminology of representation and sign type. For text, top-down and bottom-up processing guides an initial representation of the surface of the text (Schnotz & Bannert, 2003). Therefore, the symbols of the text are naturally processed while relevant prior knowledge and task goals
influence this processing. Then, semantic processing occurs which creates a propositional representation. These propositions are then used to establish a mental model of the text. This model is inspected in terms of its propositional framework and text surface representation.

For graphics, top-down and bottom-up perception guides an initial visual perception of the material (Schnotz & Bannert, 2003). Therefore, the iconic nature of the graphic is naturally perceived while relevant prior knowledge and task goals influence this perception. Then, thematic selecting occurs which creates an overall mental model. This mental model is then used to establish a propositional framework of the graphic. The propositional representation is inspected in terms of its mental model and previous visual perception of material.

For both text and graphics, the resulting mental model and propositional representations demonstrate the creation of both descriptive and depictive internal representations (Schnotz & Bannert, 2003). Therefore, regardless of whether an external representation is descriptive or depictive, the internal representation will include both types of representations.

In addition to Schnotz’s (2002) integrated model, Schnotz (2008) has also found that mental model construction is highly dependent on what form of visualization is presented. For example, a mental model construction of a round object that results from a round visualization versus a mental model construction about the same round object with a flat visualization could result in different mental models. Therefore, external representations can have a strong effect on resulting internal representations.
Consequently, it is important to understand particular types of visualizations in order to fully understand their specific effects on internal representations.

**Study of Visualizations**

Currently, many studies have been conducted on visualizations, but there is still a great deal of information that is not known about visualizations (Hegarty, 2011). Researching visualizations is very complicated because no two visualizations are exactly alike. Two visualizations that present the exact same information can significantly differ in their learning influence depending on how they are displayed (Hegarty, 2011). It is also difficult to generalize visualization results in one field to other fields (Tversky et al., 2002). For example, an animated display might be beneficial in the field of mechanics, but not as beneficial in the field of chemistry. In addition, efficiency of visualizations is heavily reliant on the task demands (Hegarty, 2011). Task demands indicate the goal or the purpose of a visualization. For example, the same visualization could be efficient at facilitating memorization of material but not suited to infer relationships between material. Visualization efficiency is also dependent on many factors such as spatial ability, expertise, working memory space, and structuring and sequencing of material. The most common method to understand the effectiveness of a display is to measure how accurate and efficient a participant is at answering questions following a display (Hegarty, 2011).

However, appropriate visualizations have been found to be beneficial to cognition in numerous ways. For example, visual displays allow for information to be stored externally which allows for communication between individuals (Hegarty, 2011).
Therefore, they can serve in collaborations to develop a common ground (Tversky et al., 2002). Visualizations can also organize information spatially in a way that is cognitively beneficial and eases understanding of relationships (Hegarty, 2011). They can make complex ideas more simple by freeing up working memory space and allowing for more efficient information processing (Tversky et al., 2002). In addition, some information is more easily understood and cognitively processed when it is perceived in a visual manner (Hegarty, 2011). Therefore, visualizations can also facilitate organization of thought (Tversky et al., 2002).

**Visualizations in the Courtroom**

Although multimedia materials are presently being used in the courtroom to teach and persuade jury members, there is little evidence regarding the effects of these materials (Feigenson, 2010). Of the research that has been conducted, the findings are very mixed. In some cases, visual evidence has been shown to influence decision making and judgments, while in other cases, visual evidence has shown no effect on decision making or has been shown to actually impair judgments. However, jurors are expected to not only learn the evidence presented to them, but they are also then asked to make judgments and important decisions about this information (Feigenson, 2010). Therefore, understanding how visualizations can play a role in this process would be fundamental to case construction (Feigenson, 2010).

More specifically, little research has been done on PowerPoint visualization materials that are employed in court simply as visual aids to facilitate comprehension, recall, and judgments (Feigenson, 2010). Instead, research has focused more on
emotional and possibly biasing visualizations materials in the courtroom. These later materials are of utmost importance to the court of law, because the presentation of evidence should never distort judgments or cause emotional or psychological trauma (Feigenson, 2010). Consequently, the focus of current research is highly informative about the necessary restrictions on visualization materials, but does not provide information about how visualization aids can facilitate recall and decision making. Therefore, we would like to examine how static, static-sequential, and animated visualizations could influence recall and decision making.

Static, Static-Sequential, and Animated Research

Overall, research on the benefits of animated versus static graphics is contradictory and mixed (Tversky et al., 2002). Two major confounds are concerned with the content of the materials as well as the procedures of interacting with these materials during animated versus static research. Often, the content between animated versus static graphics is not held constant (Tversky et al., 2002). Without holding the content steady across conditions, it is difficult to infer whether the animated or the static nature of material has an effect on learning.

In addition, previous research has sometimes provided different procedures for interacting with animated graphics, by introducing participant interactivity (Tversky et al., 2002). This also makes it impossible to conclude that the animation versus the static nature has any effect. Moreover, interactivity has been shown to influence learning, so incorporating interactivity could bias the amount of influence that animated or static graphics intrinsically have (Tversky et al., 2002).
There is also a trend in animation research to focus on studying complex animations (Tversky et al., 2002). This does not allow for a direct examination of the influence of animation uniquely, but rather provides a mixed understanding of how animations can aid in the comprehension of complex material.

**When Animations are Beneficial**

In light of the inconsistent animation research, we will examine a few studies that highlight situations when animations have been found to be useful. The following studies are in support of our hypothesis that animated graphics with violation of expectations could be more influential than static graphics. We will begin with an overview of the field.

Höffler and Leutner (2007) conducted a meta-analysis of twenty-six dynamic versus static visualization studies. The ending results indicated a “medium-sized overall advantage of instructional animations over static pictures” (Höffler & Leutner, p. 722, 2007). In addition, after exploring specific factors individually, they found that animations had stronger effect sizes when the graphics were representational and not decorational, and when the graphics were highly realistic. Therefore, there could be very specific instances when animated graphics are more beneficial than static graphics.

Another issue that Höffler and Leutner (2007) explored is the limited capacity of working memory that is sometimes maximized or surpassed in animated displays. If an animation does not allow for a permanent installment of an image once it is presented, and that particular image in the process disappears, that image must be kept in working memory and is at the risk for being lost or misinterpreted (Höffler & Leutner, 2007). However, it is possible for an animation to retain all of the presented information, thereby
eliminating this limited capacity effect in terms of temporality. If all of the information that is to be learned can continuously be compared to previous information presented the risk of taxing the temporal limits of working memory could be greatly reduced.

In a more particular study, Boucheix and Schneider (2009) explored the differences of comprehension between sequential static presentations and animated presentations. Four presentation styles were examined: 1. dynamic 2. single-static-frame 3. sequential static frames that remained present with the introduction of new frames (“integrated”) 4. sequential static frames that disappeared with the introduction of new frames (“independent”). Hypotheses were based on cognitive processing limitations of attending, perceiving, and processing information that is changing. Results confirmed that dynamic presentations and sequential-integrated-static presentations affected and improved comprehension more than sequential-independent-static presentations and single-static presentations. Therefore, sequentially presenting material in an integrated fashion was shown to have similar effects on comprehension as dynamic presentations.

Imhof and colleagues (2012) expanded on this research idea by conducting two studies on the effects of perceptual learning according to dynamic versus static visualizations.

The first study explored dynamic visualizations versus two versions of static visualizations—static-sequential and static-simultaneous—in order to also understand if the type of static presentation format could have a different effect on learning. However, the static sequential condition removed photos when new information was presented, while the static-simultaneous presentation presented all information at once. Therefore,
the static-simultaneous presentation adds another condition to Boucheix and Schneider’s (2009) study, by having a simultaneous-integrated-static condition.

Results indicated that when participants were asked to perform tasks that were intermediately difficult, participants were significantly better at classifying locomotion performance in the dynamic visualization condition versus the static-sequential condition, but were not better than the static-simultaneous visualization condition. Therefore, if the static visualizations were permanently visible, the classification score was similar to the dynamic visualizations. Consequently, these results implied that if the limited space of working memory was not forced to hold information according to temporal factors, performance was higher.

However, in order to understand the static-simultaneous visualizations further, Imhof and colleagues (2012) conducted a second study where they varied the spatial arrangement of the visualizations. For, in the previous study, the static-simultaneous visualizations were arranged in rows. Therefore, they added three different spatial arrangements of either columns, matrices, or circles in order to test if the arrangement had any effect. In fact, the scores demonstrated opposite results than the first study. Participants presented with dynamic visualizations actually performed better than participants presented with static-simultaneous visualizations when they were arranged in columns, matrices, and circles.

Therefore, dynamic visualizations continuously outperformed both static conditions (i.e. static-sequential, static-simultaneous) unless the static-simultaneous visualizations were presented in rows. Consequently, dynamic visualizations are not always considered beneficial, but in this case, they scored higher than most static
visualization formats. In addition, reducing the amount of strain on limited working memory by presenting simultaneous information was only conditionally beneficial according to the spatial arrangement of material.

Overall, this study provides more support to the important consideration of temporality of material, but from a static visualization perspective. Permanent information presented in the first study received higher scores than transient information. However, in the second study, results indicated that not all temporally equal presentation formats effect learning in the same way and that the spatial arrangement of material is important.

**Cueing Effects in Animations**

Amadieu and colleagues (2011) argue that cueing can serve to reduce the attentional cognitive resources that are allocated to select and process relevant information. If these processes are freed by cueing relevant information, there are more cognitive resources available to do other cognitive tasks, such as comprehending material. In a particular study, Amadieu and colleagues (2011) explored the influence that cueing can have on comprehension of animations. In two animated conditions, cueing was either present or removed. Cueing was defined as zooming in on relevant important information. In addition, both conditions were presented the same material three times. Measures of subjective cognitive load and comprehension were conducted, both on isolated elements of definitions as well as high-element interactivity material. However, questions were only presented after the first and third trial, providing no data about the success of the second trial. Therefore, desired improvements could have occurred at the second exposure, but there is no data to defend this hypothesis.
Results indicated that following three exposures to the cueing condition, there was a reduction in extraneous cognitive load. The cueing condition also showed a higher level of comprehension of the high-element interactivity material, but scored similarly with the regular animated condition on comprehension of isolated element materials. Lastly, the cueing condition was found to be more capable of developing an elaborate mental model of the material and conducting problem solving transfer tasks. These results provide support to the attention guiding principle that shaping learners’ attention to necessary aspects for learning can positively influence comprehension and learning (Amadieu et al., 2011).

Another study on the effects of cueing in animations was conducted by de Koning and colleagues (2007). However, instead of zooming in on relevant material, a visual cue was introduced that highlighted the important information to be learned. Interestingly, participants in the cueing condition performed higher on comprehension and transfer tasks referencing cued information, but also performed better on comprehension and transfer tasks referencing uncued information. Therefore, it could be argued that if the cueing condition releases cognitive resources by removing the task of selecting important information, there are more cognitive resources present to process and understand all material. This study also gives support that various methods of cueing are beneficial.

Following these results, de Koning and colleagues (2010) conducted another study on animation and visual cues using eye tracking equipment. Hypotheses were confirmed that participants would have longer fixations on cued material and would look at cued material more often. However, scores on comprehension and transfer tasks
showed no significant difference between the regular animated condition and the animation with visual cues condition. Therefore, even though attention was appropriately guided in the cueing condition, there was no effect on the resulting comprehension and transfer ability of participants.

Although, data was also collected regarding the amount of statements that participants made following exposure to the material (de Koning et al, 2010). Results from this performance data indicated that participants in the cueing condition significantly made more statements about the material than the regular animated condition. Therefore, it could be possible that participants would actually have stronger judgments if presented with a cued animation because they have more things to say about the material.

De Koning (2011) and colleagues then conducted another study in order to determine if the rate of presentation had any influence on enhancing cognitive processing in cueing with animations. All four animation conditions illustrated five subsystems of the cardiovascular system across six cycles. However, the animated conditions were split into four groups. Group one and two consisted of regular animations that were presented at either a low ("4 frames per second [fps]"") or high speed ("24 fps"), while groups three and four consisted of cued animations that were also presented at a low or high speed (de Koning et al., 2011). The goal of the study was to understand when cueing could be more beneficial, and if coupling cueing with a high speed animation would enhance learning. However, results did not show any differences on comprehension and task performance between any of the conditions. Therefore, speed of animation was not influential.
The results of all of the previously mentioned studies provided evidence and support for how static and animated presentations can affect recall. However, there is no evidence of how this recall would influence consequential decision making.

Jury Decision Making

The ultimate goal of a jury is to come to a consensus about the verdict of a case (Feigenson, 2010). This decision of guilt is deliberated on between jury members until a final decision can be made. However, individuals first make their own decisions of guilt which they carry with them into deliberation (Casper et al., 1989). This individual decision can be influenced by many individual factors as well as psychological factors, such as the hindsight bias (Casper et al., 1989).

Devine and colleagues (2000) conducted a meta-analysis of 206 studies regarding jury decision making. Several models have been utilized to outline how jurors make decisions, but the most commonly used model is the “story” model (Devine et al., 2000). The story model was created by Pennington and Hastie (1986, 1988) in order to explain how jury members made decisions. In this model, jury members make decisions by evaluating evidence in terms of a story that jurors individually create from case materials. This story is influenced by individual differences, but includes a coherent representation of the case. Within this story, several factors have then been shown to influence jury decisions:

... definition of key legal terms, verdict/sentence options, trial structure, jury-defendant demographic similarity, jury personality composition related to authoritarianism/dogmatism, jury attitude composition, defendant criminal history, evidence strength, pretrial publicity, inadmissible evidence, case type, and the
initial distribution of juror verdict preferences during deliberation. (Devine et al., 2000, p. 622)

Therefore, jury stories and decisions can be extremely complex and heavily influenced by many different factors.

Pennington and Hastie (1992) explored the model further by testing how story structures influenced decision making. In the model, jurors actively engage with case materials in order to create a cohesive mental representation of a case. Therefore, influencing the construction of this mental representation would have a direct effect on resulting decision making. Thus, Pennington and Hastie (1992) presented participants with different case backgrounds, with half case backgrounds enabling easier story construction, and the other half reducing story construction ease. Results indicated that both groups recalled the same amount of material. However, if story construction was facilitated, judgments of guilt or innocence were significantly stronger than when story construction was hindered. Therefore, establishing a coherent story is highly influential in verdict judgment.

In a particular study on story creation, Casper and colleagues (1989) examined how hindsight bias influenced participants’ decisions about damage awards. Hindsight bias can influence decisions when individuals let outcome information influence their perceptions or stories about previous information that should be independent from the outcome. Participants were presented with a case background and opposing arguments. The case was to determine the amount of actual and punitive damages that should be awarded to a man who was searched by the police. The man received bodily harm and damage to his apartment due to the search. The only thing that varied between
participants was the presentation of the outcome of the search. One third of participants were told that the search resulted in locating illegal evidence, one third were told that the search did not result in any illegal evidence, and the remaining third were not told the results of the search. Participants who were told about the outcome of the search were instructed to not take this information into account while assigning guilt to the police officer. Participants were then asked to determine how much money should be awarded for the actual damage caused as well as how much money should be awarded to punish the officer.

Results supported the hypothesis that hindsight bias influences jury decision making, even if jurors are instructed to not consider certain information in their decision. When participants were informed that the search found illegal evidence, and was therefore successful, participants awarded significantly less damage awards. However, if there was no mention of the success of the search or if the search was not successful, damage awards were significantly higher. Therefore, jurors awarded significantly different damages awards, according to the level of guilt that was perceived due to the outcome of the search.
CHAPTER III

METHODOLOGY

Design

One factor, graphical representation, was varied across three conditions: static, static-sequential, and animated. The resulting design was a 1x3 fixed analysis of variance of graphical representation type.

Participants

One hundred and two undergraduate participants (70 percent female, 30 percent male) were randomly assigned to either the static, static-sequential or animated condition. Volunteer participants were selected from sign-up sheets at a medium-sized university in northern California, United States. Demographics were taken to reflect information that is important for jury selection. Participants ranged from eighteen to fifty-one years of age (M = 22.91, SD = 5.68). Ninety-four participants reported that they were single, four percent reported that they were married, and two percent reported being divorced. Total gross family income revealed that thirty-two percent of respondents had a total family income less than $20,000, seventeen percent had a total family income between $20,000-50,000, twenty percent had a total family income of $50-100,000, eighteen percent had a total family income of $100-200,000, three percent had more than $200,000, and eleven percent declined to state or did not know the total value. Fifty-seven percent were White/Caucasian, thirty percent were Hispanic/Latino, four percent were Asian, two percent were Native American/American Indian, two percent were African American/Black, and six percent reported other. Ninety-seven percent of
respondents had never had jury duty before, while three percent had participated in jury
duty before. Eleven percent of respondents knew someone that had a revision surgery in
their lifetime. However, these data sets were checked for any outliers, and none of these
data sets had to be omitted. Overall, three data sets were omitted because participants did
not follow instructions.

Experimental Materials

The experimental materials employed in this investigation included a case
background, one experimental graphic, three forms of temporal presentation of the
graphic, a demographic data sheet, a measure of the recall of the graphic, and a
questionnaire involving decision making questions pertaining to the case.

Case Background

The case background was a 217-word expository text including 13 sentences,
with a Flesch-Kincaid Grade Level of 10.5. The goal of the text was to describe a medical
product liability case from the perspective of both the plaintiff and defense. In this text,
the prosecution claimed that a manufacturing company did not recall a faulty medical
product when it was appropriate to do so. The failure to recall the product resulted in
unnecessary medical revisions requiring major invasive surgery to patients as a
consequence. From the defense perspective, the manufacturing company maintained that
their product was never faulty and there was no need to remove the product from the
market due to the product’s revision rates. The content of the text was created from a real
medical product liability case and described the concept and effects of a revision. While
some details were changed in order to maintain confidentiality, it was very important to
have the case background resemble as closely as possible what the prosecution would say
in court. Therefore, several drafts were revised until lawyers working on the particular case agreed that the passage would imitate what would be presented to a jury.

**Experimental Graphic**

The graphic displayed a simple bar graph of real revision rate data across a three year time span. Each year contained data for both the product in question and other similar products on the market. Due to confidentiality and an effort to minimize any attribution of attitudes to the name of the company, the legend referred to the bars on the graph as “product” and “other products.” At each year, on the x-axis of the graph, the “product” bar and “other products” bar were placed directly next to each other to facilitate comparisons at each year (Kosslyn, 2006). Then, spaces were added between years to facilitate chunking of the years and to facilitate comparisons between years (Kosslyn, 2006). Thus, the x-axis was labeled “Year 1,” “Year 2,” “Year 3,” respectively. The y-axis was labeled “percent” and was numerated from zero to fifty-five percent. The highest bar reached forty-five percent.

The revision rate values presented as bars on the graph showed the proportion of “product” to “other products” rising at each year interval. At “Year 1,” the “product” bar was two times the size of the “other products” bar. At “Year 2,” the “product” bar was four times the size of the “other products” bar. Then, at “Year 3,” the “product” bar was increased to fifteen times the size of the “other products” bar. This disproportionate increase of the “product” bar in Year 3 relative to Year 1 and Year 2 was regarded as sizable enough to violate the expectations of viewers since the “product” bar would only be expected to be eight times the size of “other products” at Year 3, based on an extrapolation of the data from the previous two years.
The six bars (three “product” and three “other products”) were shown in each of three graphs. Thus, while each graph depicted identical data, the graphs varied in the way the bars were presented. In the static condition, all six bars were shown simultaneously as one intact graph. In the static-sequential condition, the two bars at Year 1 were presented as a whole first, followed by the two bars at Year 2, and subsequently the two bars at Year 3—each year bar-pair presented sequence. The graph in the animated condition presented each year bar-pair in a similar fashion to the static-sequential condition, but the bars were animated to grow vertically from the x-axis.

**Figure 1.** Experimental Graphic.
**Graph Construction**

In order to study how a violation of expectations affects visualization processing, it was important to use a graphic that followed graphic design principles. In this way, it was possible to examine the particular effect of the violation, without confounding factors of poor graph construction. Below, we will describe several graphic principles, from both Kosslyn and Mayer and Moreno, that were employed in the construction of our bar graph.

*Kosslyn*

Kosslyn (2006) has developed several principles for graph construction. The principle of discriminability and the principle of perceptual organization were relevant to our study. First, the principle of discriminability advises that in order for a learner to perceive differences between two items, they must be different enough so that the learner can in fact perceive the difference. Therefore, in order for comparisons to be encouraged between variables at each step, we assured that differences could be made between shades of the variables so that a difference could be detected. We also included a legend to ensure that the learners knew what variables these shades referred to.

Secondly, the principle of perceptual organization states that information will be grouped together under various circumstances including the proximity of the material. If material is placed in close proximity together, it will be grouped and compared to other material. We addressed this principle by placing the variables to be compared immediately next to each other, and then placing space between the next set of variables to be compared. Then, it is possible to make comparisons of specific variable comparisons across sets.
We designed the graph according to these psychological visualization principles in order to maximize the ability of accurately processing the information and to minimize any confusion that could arise from the graphic alone. Thus, we did not want any problems in recall or decision making to be attributed to the construction of the graph.

*Mayer & Moreno*

We began by addressing Mayer (2003) and Moreno’s (2006) design principles of temporal contiguity, spatial contiguity, coherence, and personalization. Temporal contiguity postulates that learning is improved when information is simultaneously presented. This was inherently accounted for in the static condition because all of the material is concurrently presented at one time. However, in the static-sequential and animated condition, not all information is presented simultaneously. Although, when the information arrives across the animated steps, none of the information disappears. Therefore, all of the material is capable of being processed in working memory in the same time frame.

The principle of spatial contiguity states that learning is improved when information is presented and integrated in the same space. If information is presented in different spaces, information must be held in working memory across presentations while a learner focuses on other current presented material. In this way, the availability of cognitive resources are diminished. Spatial contiguity is followed across the static and bar graphs because all information is always integrated in only one graphic. This allows for simplifying cognitive processing that is required to make connections between bars.
because information is not separated and allows for all information to be accessible at once for processing.

The principle of coherence states that learning is enhanced when irrelevant material to the learning task is not presented with relevant material. Similar to the argument for spatial contiguity, if irrelevant material is presented there are less cognitive resources available and learning will be lowered. Coherence is also held constant across bar graphs in all conditions by not including any information in the graphic that is distracting to the learner. Therefore, cognitive resources can be fully used to comprehend and make inferences from the graphic.

Lastly, the principle of personalization argues that material is easier to learn when the learner can relate to the material. Therefore, if learners relate to the material it can positively influence learner’s attention to material and motivation to learn, which could then guide and enhance learning. We believe that personalization is inherent in our test materials because participants are asked to assume the role of jury member and to make decisions as they would if they were actually sitting on the jury for this case. In this way, the materials are personalized to the learner because they can pretend that they making these decisions in real life, and that their decisions have meaning.

Temporal Presentation of the Graphic

All graphs had the same overall exposure time of twenty-eight seconds. The participants in the static condition were exposed to a still version of the entire graph for the full twenty-eight seconds.

The static-sequential presentation was broken into four 7 second increments. The first seven seconds provided the x- and y-axes, title of the graph, and legend in order
to familiarize the participants with the graph, its scale, and its contents. The display of “Year 1” data occurred after the first 7 second increment of familiarization. Both “product” and “other products” bars for this year were displayed instantly, at the same time. The display of “Year 2” data occurred seven seconds after the display of “Year 1.” Data were presented in the same way as “Year 1”. Similarly, the display of “Year 3” data occurred seven seconds after the display of “Year 2.” Finally, the full graph remained on the screen for an additional seven seconds. Consequently, in the static-sequential condition, the bars were static on the screen, but were revealed sequentially by increments of seven seconds.

The animated presentation was also broken into four 7 second increments. The first seven seconds provided the x- and y-axes, title of the graph, and legend in order to familiarize the participants with the graph, its scale, and its contents. The display of “Year 1” data began after the first 7 second increment of familiarization. The growth of both “product” and “other products” bars for this year were animated, growing from the x-axis to their respective heights in three seconds. This left four seconds to view the final heights of the bars with no animation occurring on the screen. The display of “Year 2” data began seven seconds after the beginning of the display of “Year 1.” Data were animated in the same way as “Year 1”. Similarly, the display of “Year 3” data began seven seconds after the beginning of the display of “Year 2.” Finally, the full graph remained on the screen for an additional four seconds. Consequently, in the animated condition, yearly data was presented sequentially, and the growth of each bar was animated.
Recall of the Graph

Recall of the graph was our first dependent measure. Recall was measured by providing participants with a template of the graph and asking them to re-create the graph as accurately as they could. The x- and y-axes, the title, and legend were provided as a framework. In addition, straight vertical lines were added to indicate each year, and dotted lines were placed in the middle of each year to indicate where each missing bar should be placed. This was done in order to receive uniform re-creations of the graph that were comparable.

Decision Making Questionnaire

Decision making was our second dependent measure. The decision making questionnaire included two questions pertaining to guilt. The first question was established by researching how similar studies assessed guilt. Likert scales ranging from “Not Guilty” to “Guilty” were the most commonly used assessments, so we used a Likert scale from 1 to 12 to measure guilt (1-not guilty to 12-guilty). We chose to use such a large Likert scale due to a ceiling effect that occurred during piloting. When presented with a seven point Likert scale, all participants found the company very guilty, and we wanted to be able to detect any differences between groups at a higher level of granularity. Following guilt assessment, there was a seven point Likert scale of confidence in guilt assessment (1-not very confident, 7-very confident).

The second question pertaining to guilt was a multiple choice question assessing when participants thought the company should have recalled the product (a-Year One, b-Year Two, c-Year Three, d-Can Not Decide). There was also a seven point confidence scale after this question (1-not very confident, 7-very confident). The
remaining two questions were about penalties that participants felt the company should receive. First, participants were instructed that the penalty in product liability cases is to compensate the victims with money and that jury members must make the decision on how much money to provide to victims. Then, two questions were asked regarding how much compensation participants thought should be awarded to victims for surgery fees and for pain and suffering. Amount for surgery fees and pain and suffering were both 7 point Likert scales (1-no compensation, 7-full compensation).

Procedure

Participants entered a computer lab on the university campus and were randomly directed to prepared computer stations. Participants were asked to read and sign an Informed Consent before being given explicit instructions about their task. If participants elected to participate, they were asked to view a PowerPoint presentation that was guided by participants’ clicking to advance the PowerPoint slides. However, participants were not allowed to continue until everyone was on the same slide. Therefore, between each slide of information was a wait page to ensure that everyone was on the same slide at the same time.

While on a slide containing information, participants were instructed to only click when they felt that they had fully read and understood the text on the screen. The final slide contained the graph. However, the exposure time for the graph was automatic and consistent across conditions (28 seconds). Following the PowerPoint presentation, participants completed a demographics questionnaire and answered distractor questions that pertained to law. This was done to ensure that when participants recalled the graph,
they were not simply reproducing the graph from short-term memory, but rather reconstructing the graph from long-term memory. After completing these distractor questions, participants were asked to re-create the graph from memory to the best of their abilities. When participants completed their graph reconstruction task, they were asked to fill out a decision making questionnaire about the case consisting of six jury based decision making questions. Finally, the procedural sequence ended with a debriefing sheet, after which the participants were thanked for their participation and excused.
Figure 2. Session Site Map.
CHAPTER IV

RESULTS

Data Source

Participants’ recall of the height of each bar in the graph was scored in units of millimeters. Graphs were blindly scored before being matched with condition. Twenty percent of graphs were randomly chosen to be scored by two independent raters to ensure that there was no bias in scoring. An Intraclass correlation (ICC) yielded a value of $r(20) = 1.00, p < .001$. All millimeter scores were then converted into percentages in relation to the scale on the original graph.

The decision making questionnaire was scored according to each question’s Likert scale.

All measures that were put in the basic experimental design were accepted as significant with an alpha level ($\alpha$) less than .05.

Analysis of Graph Recall

Scores of participants’ recall were subtracted from the actual value of each bar to obtain difference scores to the actual graph. Therefore, positive scores indicated how much a participant overestimated a particular bar, and negative scores indicated how much a participant underestimated a particular bar. However, in order to understand the degree of recall error, we converted accuracy scores into their absolute values. With these absolute values we were able to determine how far from the actual graph a participant recalled the graph.
The absolute value of the accuracy scores were entered into a 3 Condition (static vs. static-sequential vs. animated) X 2 Product Type (product vs. other products) X 3 Year (Year 1 vs. Year 2 vs. Year 3) fixed ANOVA, with repeated measures on the product type and year variables. The design yielded a main effect for product type (product vs other products), $F(1, 99) = 6.40, p = .013, \eta = .25$. Participants across conditions were significantly less accurate at recalling the “product” ($M = 3.76, SD = .26$) than the “other products” ($M = 3.01, SD = .26$).

![Amount of Error - Product Type](image)

*Figure 3. Amount of Absolute Error According to Product Type.*

The design also revealed a main effect for year (Year 1, Year 2, Year 3), $F(1, 98) = 37.06, p < .001, \eta = .52$. Post-hoc Bonferroni tests showed that participants were significantly less accurate at recalling products (both the “product” and “other products”) at year three ($M = 4.54, SD = .36$) than at year one, $p < .001, (M = 2.3, SD = .14)$ and at
year two, $p = .006$ ($M = 3.31, SD = .33$). Also, participants were significantly less accurate at recalling the products (“product” and “other products”) at Year 2 ($M = 3.31, SD = .33$) than Year 1, $p = .001$ ($M = 2.3, SD = .14$). Therefore, Year 1 was the most accurately recalled year.

![Amount of Error - Year](image)

*Figure 4.* Amount of Absolute Error According to Year.

An interaction was also found between product type and year, $F(1, 99) = 5.98$, $p = .016$, $\eta = .24$ (Figure 5). At Year 1, participants were significantly less accurate at recalling the “product” bar ($M = 3.07, SD = .21$) compared to the “other products” bar ($M = 1.54, SD = .09$), $F(1,99) = 79.85$, $p < .001$. At Year 2, participants were also significantly less accurate at recalling the “product” ($M = 3.90, SD = .50$) compared to the “other products” ($M = 2.72, SD = .23$), $F(1, 99) = 8.67$, $p = .004$. At Year 3, no
significant difference was found between recall of the “product” \((M = 4.77; SD = .56)\) and “other products” \((M = 4.32; SD = .50)\) bars.

![Product Type Error by Year](image)

*Figure 5. Amount of Absolute Error According to Product Type by Year.*

No significant interactions were found for product type by condition, year by condition, or product type by year by condition. However, an interesting phenomenon occurred that can be seen below in Figure 6. For the other products, regardless of condition, participants increasingly overestimated the bars across all three years. However, regardless of condition, this relationship did not occur with recall of the product bar. Recall was similarly overestimated within each condition for the first and second year, but at year three, all three conditions underestimated the bars. Therefore, recall of the product bar at year three was the only bar to ever be underestimated.
Analysis of Decision making

A separate one-way fixed analysis of variance (ANOVA) was conducted on all six decision making questions: guilt, guilt confidence, year of recall, confidence in recall, compensation for surgery fees, and compensation for pain and suffering. Results indicated that compensation for pain and suffering was significant, $F(2, 99) = 3.73$, $p = .027$, $\eta = .26$. Post-hoc Bonferroni tests indicated that there was a significant difference ($p = .038$) between the animated ($M = 5.95$, $SD = .97$) and static-sequential ($M = 5.14$, $SD = 1.31$) condition. Therefore, participants in the animated condition awarded more money to patients than in the static-sequential condition.

Due to our hypothesis and the nature of the data, we decided to run two independent samples t-tests on guilt and guilt confidence in the static versus animated condition. Results of this test indicated that participants in the animated condition ($M =$

Figure 6. Amount of Accuracy Error According to Product Type by Condition by Year.
5.94, SD = .94) had significantly higher confidence in their decision of guilt than participants in the static condition (M = 5.36, SD =1.12), t(67) = -2.32, p = .024.

![Guilt Confidence](image)

**Figure 7.** Static Versus Animated Guilt Confidence.

No significant difference was found between the animated (M = 8.34; SD = 2.36) and static (M = 8.96; SD = 1.50) condition for decision of guilt.

Due to the significant correlation between guilt confidence and decisions of guilt, r(102) = .28, p < .001, we multiplied the two scores to obtain a weighted guilt measure. However, still no significant differences were found with these weighted measures.

In addition to being highly significantly correlated to decisions of guilt, guilt confidence was also significantly correlated to confidence in recall, r(102) = .61, p < .001. Guilt confidence was also significantly correlated to monetary award decisions of
compensation for surgery, $r(102) = .31$, $p = .002$, and compensation for pain and suffering, $r(102) = .28$, $p = .004$. Therefore, participants with higher judgments of guilt confidence not only made stronger decisions of guilt, but also decided that patients deserved more compensation for surgery fees, pain, and suffering, and were more confident in their decision of when the company should have recalled the product.

Guilt was significantly correlated to confidence recall, $r(102) = .33$, $p = .001$, and compensation for surgery fees, $r(102) = .21$, $p = .03$. However, guilt was not significantly correlated to compensation for pain and suffering.
CHAPTER V

DISCUSSION

This investigation was designed to expand current instructional visualization research to the field of litigation. In particular, this investigation aimed to explore how a violation of expectations could influence visualization processing by the study of three test graphics: static (no violation of expectations), static-sequential (violation of expectations), animated (double violation of expectations). Specifically, we were interested in the practical applications of how a visual violation of expectations could influence decision making in a courtroom case. Furthermore, we were interested in examining if this decision making could be influenced by variations in recall for expectancy-violating material.

As mentioned in the introduction, previous violation of expectations research has focused on the attentional capture of expectancy-violating material (Wang et al., 2004; Camras et al., 2002; Parmentier et al., 2010; Baker & Anderson, 1982; Vachon et al., 2011). However, we were interested in researching how this attentional capture could influence cognitive processing. We hypothesized that the attentional capture that results from a violation of expectations would increase recall accuracy of specific expectancy-violating material. Conversely, we also hypothesized that this direct attentional capture would then influence mental representations of initial material by means of hindsight bias. Therefore, that recall of initial material would be biased towards the direction of expectancy-violating material. We also argued that static-sequential and animated
representations would not score as similarly as they have in the past if a violation of expectations was introduced (Boucheix & Schneider, 2009; Imhoff et al., 2012).

Results for this hypothesis were not significant. However, an interesting pattern emerged. Recall of all non-expectancy violating material across all three years and conditions was overestimated. However, across conditions, recall of the product bar at year three was underestimated. Therefore, expectancy-violating material was the only bar to be underestimated. Although this means that the static condition also produced the same results, the static-sequential and animated condition resulted in less magnitude of underestimation than the static condition.

These results could have been due to the framework of the graphic used to measure recall. In order to assure that the recalled graphs could be compared between participants, the x- and y-axis were provided. Therefore, the height of the y-axis could have uniformly influenced overestimations of the non-expectancy violating material because these bars were rather small in the actual graph. Consequently, there could have been an inherent pressure to draw the bars higher for non-expectancy violating material than the expectancy violating material. This could also explain why the expectancy-violating material was underestimated, as participants tried to use the y-axis as a frame of reference. In this case, participants could have assumed that the bar should not be close to the height of the y-axis and thus drew the bar to be shorter than the actual graph.

Therefore, the format of the recall task could have masked any influences of a violation of expectations. It could have been more beneficial to do a complete free recall task and compare proportional differences within participants between participants. In addition to the possible influence of the y-axis, it is possible that the graph was actually
too simple to witness any effects between groups. Therefore, a slightly more complex graphic could have increased the magnitude of these results.

However, even though no differences were found between conditions, several overall effects were found. In particular, participants were less accurate at recalling the products versus the other products. This could be related to many factors. One influential factor could be due to the design of the graph and the size of the product bars. The product bars were larger than the other products, so the amount of error could be inherently due to the height of the bars. In addition, the other products grew at a steady rate, where the product bars did not. Therefore, it could have been more difficult to develop a consistent mental model with the product bars.

Additionally, across conditions, participants produced the highest amount of recall errors for both the product and other product bars at year three. This could also be in part due to the large size of the product bar at year three. Furthermore, it could be due to the difficulty in incorporating year three into a consistent mental model with year one and year two.

This can be seen further with the differences in product versus other product recall at each year. At year three in all conditions, no significant difference was found between the other product and product, and both scored together the highest amount of errors across all three years. However, at year one and year two, recall of the product bar induced significantly higher errors that the other products. Therefore, year three could have been negatively detrimental to recall across all conditions, and the expectancy violation of the product bar could have negatively influenced recall across all conditions.
However, this would indicate that there was some degree of violation present in the static condition.

Consequently, the conclusion from the recall errors highlighted that there were no real differences between conditions. Therefore, regardless of condition, recall of the graph was similar. Significant differences were found according to year and type of product, but these differences could be attributed to the data, not to the representation format.

However, even though all three groups scored similarly on graph recall, they did not make the same decisions regarding the case. This result is particularly interesting because it indicates that perception of the graph was not the main influential factor in final decision making. Participants in the animated condition awarded significantly more money to patients for pain and suffering than participants in the static-sequential condition. In addition, participants in the animated condition reported that they were more confident in their decision of guilt than participants in the static condition. However, it is important to note that the animated condition scored significantly different than both the static-sequential and static condition. Therefore, the animated condition influenced the highest amount of impact on decision making.

This result could have been influenced by the amount of surprise that was witnessed in the highest violation of expectations condition. We hypothesize that this surprise could have had an emotional effect on participants’ decision making. Therefore, even though the cognitive process of perception did not differ between groups, the way that participants felt after seeing the graphic could have influenced their decisions.
Limitations

One large limitation is that we did not provide a measurement for surprise. With no measurement, we are incapable of determining if our hypothesis regarding decision making outcomes is supported. In addition, we did not provide a measurement for graphicacy of bar graphs. If we had included this measurement, we could have determined if recall accuracy was due to the materials or if recall accuracy was actually due to individual differences. Also, in our attempt to develop a graph that did not produce too much complexity, it is possible that our graphic was too simple. Thus, possible differences between recall could not be found due to a ceiling effect.

Furthermore, we assumed that the attentional capture found in previous violation of expectations research would occur. However, we do not know the extent of this attentional capture, or how attention was guided in the static condition. Therefore, it would have been more accurate to conduct an eye-tracking experiment in order to record attentional behaviors.

Lastly, in order to accurately generalize these results to the courtroom, two main factors would have to occur. First, it would be more generalizable to provide a more in-depth, realistic, description of the case. However, time constraints make this factor rather difficult to realistically obtain. Our study provided a very brief overview of the case, which could have led to less engagement with the material and to fewer impacts from the material on recall and decision making. Second, it would better to have a mock lawyer present the information in person while simultaneously presenting the graphic material. In this way, the study would be more ecologically valid.
Implications for Future Research

Ideally, future litigation visualization research would incorporate mini mock trials. This method would be the most ecologically valid study construction, and would provide the highest generalizable results to a real courtroom setting. As for the future of visual violation of expectations research, several factors should be considered. For example, research should be conducted on the emotional effects of a violation of expectations. In addition, it would be interesting to examine how multiple violations could affect cognitive processing; such as, exploring if multiple violations would increase attention and engagement with material, or if multiple violations would discourage attention and engagement with material. Furthermore, it would be beneficial to explore how a more complex visual violation of expectations could influence processing and decision making. It would also be extremely beneficial to examine these effects over time. It is possible that a violation of expectations could induce stronger effects over an extended period of time.

Implications for the Courtroom

Our results provide support to the influence of a violation of expectations on jury decision making. In particular, animating material that can induce a violation of expectations was shown create higher confidence in guilt and positively influence monetary awards decisions. Therefore, more research should be conducted on how different forms of expectancy-violations can influence jury decision making. Then, we would be able to further explore the behavioral effects of inducing the emotional effect of
surprise in a jury. Therefore, again it is very imperative to incorporate a strong measure of surprise in future litigation law violation of expectations research.

Across conditions we also found several interesting correlations that could be explored further in litigation research. For example, the degree of confidence that participants had in their guilt decisions was a stronger predictor of overall monetary award decisions than actual decisions of guilt. Therefore, it would be advantageous to study if this phenomenon occurs with non-expectancy violating material, or if expectancy-violating material influences this trend. In addition, it would be interesting to understand what provokes a high level of guilt confidence. It could be that participants in our study were surprised by the information which influenced their confidence scores. Therefore, further exploring the effects of surprise on confidence as well as decisions of guilt would provide a deeper understanding of jury decision making.
REFERENCES


