Belief revision in the context of reading comprehension

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Belief revision in the context of reading comprehension

Abstract
The goal of the present experiments was to explore the underlying cognitive processes that support individual belief revision. In three experiments the amount of relevant information pertaining to a misconception was systematically manipulated to assess the impact of text refuting a misconception and text explaining the correct information. Experiment I assessed the impact of the refutation. Experiment II assessed the joint impact of the refutation and the explanation. Finally, Experiment III assessed the impact of the explanation. Experiment I demonstrated that providing a refutation section that explicitly negated the misconception was sufficient to eliminate disruption when reading a sentence that contained the correct information. When the explanation was provided in Experiment II, the effect of the refutation increased significantly. Experiment III provided a close replication of effects found in Experiment II. The results of all three experiments support the use of text to enable the initial stages of belief revision.

Keywords
Psychology, Cognitive
This thesis has been examined and approved.

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DEDICATION

For Ted.
ACKNOWLEDGEMENTS

I would like to thank my friends and family for their support throughout this process. I am lucky to have each one of them in my corner. I would also like to thank my advisor Ed O’Brien. I am privileged to have his continued guidance and look forward to learning much more.
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ABSTRACT

BELIEF REVISION IN THE CONTEXT OF READING COMPREHENSION

by

Erinn K. Walsh

University of New Hampshire, September, 2011

The goal of the present experiments was to explore the underlying cognitive processes that support individual belief revision. In three experiments the amount of relevant information pertaining to a misconception was systematically manipulated to assess the impact of text refuting a misconception and text explaining the correct information. Experiment I assessed the impact of the refutation. Experiment II assessed the joint impact of the refutation and the explanation. Finally, Experiment III assessed the impact of the explanation. Experiment I demonstrated that providing a refutation section that explicitly negated the misconception was sufficient to eliminate disruption when reading a sentence that contained the correct information. When the explanation was provided in Experiment II, the effect of the refutation increased significantly. Experiment III provided a close replication of effects found in Experiment II. The results of all three experiments support the use of text to enable the initial stages of belief revision.
INTRODUCTION

In order for a reader to comprehend a text they must continually integrate what they are currently reading with what came before. Often times successful integration requires the reader to make inferences to fill in the gaps between explicitly-stated text. This inferential information becomes part of the representation of the text. Each time the reader encounters new information that information as well as the contents of working memory (WM) sends a signal to all of memory. All information related resonates in response to this signal and the information that resonates to the highest degree then becomes readily available and serves to guide comprehension.

The current thesis will focus on this comprehension process, using a memory-based approach. In the first chapter I will address past models of comprehension. I will then describe more current models of comprehension in chapter two. In chapter three I will describe how individuals incorporate new complementary or conflicting information into their representation of a text. Specifically, I will make use of common misconceptions that span several areas to assess the impact of text that contains refutations and explanations, on the ability of individuals to revise their beliefs. Finally, in chapter four I will outline the proposed research in which we explore the underlying cognitive processes that support individual belief revision.
CHAPTER I
EARLY MODELS OF READING COMPREHENSION

Text-Based

Early models of reading comprehension were designed to capture the processes and representation of the explicit information presented in the text. That is, they were focused on text-based analysis and text-based representation. Undoubtedly the most influential text-based model was, Kintsch and van Dijk’s 1978 model. Within the Kintsch and van Dijk process model there is a basic set of interconnected propositions. As a reader encodes information it will be connected as a series of propositions. Propositions are a formal unit of analysis with each proposition designed to capture a basic idea unit. Propositions consist of a predicate and one or more arguments, which are concepts or other propositions. Consider the following sentence:

1.) The truck hit the distracted jogger.

This sentence can be broken down into two propositions.

1 (Hit, Truck, 2)

2 (Distracted, Jogger)

Given the assumption of a limited capacity system, a reader cannot process an entire set of propositions all at once. There is an assumption that the reader processes text in cycles. During each cycle a reader encodes a subset of propositions (generally 7-13). The propositions are then connected on the basis of argument overlap. The representation will be a hierarchical structure composed of propositions that connect to one another based on their degree of argument overlap. According to the “leading-edge rule” important and or
recent propositions will be favored to remain in what is called the “buffer” (Kintsch & Vipond, 1979). Contents of the buffer guide the comprehension of further text. As a reader continues through a text the contents of the buffer evolve to reflect understanding. The process model suggests that comprehension difficulty occurs when there is a lack of argument overlap and thus, propositions are not well connected.

There are several problems with the process model and other text-based models of reading comprehension. First, text-based analysis is limited because the representation only captures information that is explicitly represented in the text; therefore it includes nothing that the reading brings to bare. An additional limitation is that each proposition is only able to connect to one other proposition—resulting in a hierarchical model. Intuitively this type of model fails to capture all that occurs during comprehension.

Further, van Dijk and Kitsch (1983) and many others (e.g., Garrod & Sanford, 1982a; 1982b; Johnson-Laird, 1983; Keenan, Baillet, & Brown, 1984; Sanford & Garrod, 1981) recognized that argument overlap is neither sufficient nor necessary for local coherence and that a hierarchical structure was only an approximation of the memory representation. In fact, O’Brien (1987) demonstrated evidence that a hierarchical representation failed to explain the results of an antecedent reinstatement search (see also O’Brien, Albrecht, Hakala, & Rizzella, 1995; O’Brien, Plewes, & Albrecht, 1990). This and subsequent research support a memory representation consisting of an integrated network in which text units are connected on the basis of causal relations (e.g. Cirilo, 1981; O’Brien, 1987; O’Brien & Myers, 1987; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985). Although the process model and other text-based models of comprehension fail to capture fully a complete understanding of the comprehension
process, they do outline a mechanism for the influence of variables outside of the text itself, such as world knowledge.

**Causal Models**

In order to address some of the short-comings in a purely text-based model, Trabasso and Sperry (1985) proposed a causal analysis model. According to their model, readers will make all possible causal connections between all idea units. This representation system describes the comprehension process as one of problem-solving in which idea units are causally linked until the conclusion in which all lose ends (or in this case idea units) are linked one or more other idea units.

One problem with early causal models such as Trabasso and Sperry (1985) was that there was no process model for how or when to identify causal links in the face of a limited capacity system. Fletcher and Bloom (1988) addressed this limitation by adding a process model to early causal models which they called the “current-state selection strategy” (CSS). The CSS is in many ways similar to the “leading edge strategy” suggested by Kintsch and Vipond (1979), but instead of carrying important or recent propositions in memory, the reader maintains causal relations. The reader will hold propositions in WM until they can be linked up to another proposition and conclude a causal chain. A proposition will be held in WM until encountering a likely anaphor. The causal connections will be maintained much like the “short-term buffer”. If a causal link cannot be established, a search of long-term memory (LTM) will occur.
Langston & Trabasso (1999) maintained the importance of causal relations and suggested a two step model to predict what information will be available throughout the course of comprehending a text. First, they suggest conducting a discourse analysis to identify the causal relations readers might infer between clauses. Second, they suggest using a connectionist model to calculate the integration of each new clause with the previous context on the basis of causal connections. The result of these two steps is a quantitative account for accessing information from the text. Each clause is represented by a node which is connected to one or more other nodes through causal links. Each time a new clause is added to the network, the activation level of all existing nodes as well as the strength of connections between them is updated. This result is a continuously evolving network of nodes with fluctuating activation values and causal links.

An additional way of using causal connections is through tracking the protagonist’s goals (e.g. Trabasso & Wiley, 2005). As the protagonist performs actions or events occur, the reader monitors and updates their representation. Subsequently, the reader will track the protagonist’s goals and compare them to their general world knowledge to make predictions about what the protagonist will do. These predictions or inferences will compose a network of causal connections guiding comprehension.

Although text-base and causal models have no doubt furthered our understanding of how readers break down and understand what they read, it is evident that more than just the text itself must be considered. Subsequent models address some of the inherent limitations of a text-based analysis by changing the focus to what the text is about. This shift made clear the need for a “mental model” or “situation model” that represents the situation described by the text.
**Situation Model**

The prior models of reading were focused heavily on the text-based level of the representation. van Dijk and Kintsch (1983) recognized that a list of propositions did not sufficiently capture all that occurs during reading comprehension. In response to this limitation, they proposed using a situation model to represent the story created by the text. However, Oden (1987) pointed out that a situation model representation could still be composed of propositions, as long as those propositions described the events and not just the surface structure of the text. The importance of a situation model is that the focus shifted from a text-based level of analysis to a situation level that described what the text was about. Consider the following sentence pairs from Bransford, Barclay and Franks (1972):

1a. Three turtles rested *on* a floating log, and a fish swam beneath *them*.
1b. Three turtles rested *on* a floating log, and a fish swam beneath *it*.

2a. Three turtles rested *beside* a floating log, and a fish swam beneath *them*.
2b. Three turtles rested *beside* a floating log, and a fish swam beneath *it*.

A text-based representation of the pairs indicates that both sentences pairs differ by just one proposition. However, in pair one both sentences could result in the same mental representation whereas pair two results in distinct representations. When participants were asked to memorize one of these sentences and later choose which one they had read, those who memorized a sentence from pair one had more difficulty recognizing which sentence they had learned. This evidence demonstrates that a propositional representation is not a sufficient model of comprehension and further, that readers construct some representation of the situations described by the text.
The shift toward a situation or mental model view of text comprehension made necessary an exploration of the processes involved in constructing this new level of representation. Glenberg, Meyer and Lindem (1987) suggested that constructing a mental model requires an on-going interaction between the text and the reader's linguistic, pragmatic, and world knowledge (p.69). They further asserted that a situation model representation is updatable, manipulable, and perceptual-like; It serves to guide the reader in interpreting text, forming inferences, and judging whether or not the text is coherent. Glenberg et al. tested one assumption of the situation model that the structure of an event would influence what information would be readily available to the reader. See sample passage in Table 1. They designed passages in which they introduced the reader to a protagonist and then followed by mentioning an object (e.g. sweatshirt) that was either spatially associated with the protagonist or spatially dissociated with the protagonist. They presented the readers with an item recognition procedure in which they had to report whether or not the item had been in the passage. The authors held the assumption that the situation model would capture the spatial structure of the events, therefore, the associated object should be held closer to the protagonist while the dissociated object would be unrelated and thus, further from the protagonist. By this reasoning, they hypothesized that objects in the associated condition would be recognized more quickly than objects in the dissociated condition because the structure of the situation model would keep associated objects more readily available. Using a text-based analysis, one would predict no difference between the response times because the passages were written to be equivalent in their propositional representations. Their results did show shorter response times for associated objects than dissociated objects. These
Table 1.

Sample passage from Glenberg, Meyer, & Lindem (1987)

Setting sentence:  
John was preparing for a marathon in August.

Critical (associated):  
After doing a few warm-up exercises, he put on his sweatshirt and went jogging.

Critical (dissociated):  
After doing a few warm-up exercises, he took off his sweatshirt and went jogging.

Filler:  
He jogged halfway around the lake without too much difficulty. Further along his rout, however, John’s muscles began to ache.
findings indicate that spatial structure is a part of a situation model and plays a role in
comprehension. Further, this spatial structure made some information more readily
available to the reader.

Cook, Gueraud, Was, and O’Brien (2007) extended the findings of Glenberg et al.
(1987). See sample passage in Table 2. First, they developed longer passages describing
an object as either highly associated or highly dissociated with a protagonist. For
example, Dorothy either loves her skates and always brings them to the park (associated
condition) or never brings her skates with her (dissociated condition). Several sentences
then served to background the target object, followed by a critical sentence and a
spillover sentence. The critical sentence was either consistent or inconsistent with the
information previously given about the target object. Critical sentences that were
consistent with information in the associated condition (Dorothy eagerly put on her
skates.) were inconsistent with information in the dissociated condition, and critical
sentences that were consistent with information in the dissociated condition (e.g.,
Dorothy wished she had a pair of skates.) were inconsistent with the information in the
associated condition. If protagonist-associated objects are more accessible in memory
than protagonist-dissociated objects, information about these objects should be integrated
more readily upon reading the critical sentence. Therefore reading times for the critical
sentence in the inconsistent condition should be slower in the protagonist-associated
condition than in the protagonist-dissociated. Results followed this pattern, thus
replicating Glenberg et al. (1987).

Cook et al. (2007) further expanded on these findings by implementing a naming
procedure. Naming time offers a more direct test of concept availability. To employ this
Table 2.

Sample passage from Cook, Gueraud, Was, & O’Brien (2007)

Introduction:
Dorothy loved the winter season in New England. One morning she woke up to find that there was a fresh blanket of snow on the ground. She decided to go to the local park to enjoy the winter weather.

Associated Elaboration:
Her boyfriend had recently given her a pair of customized ice skates that Dorothy always took to the park with her. Dorothy got the skates from her closet and tossed them over her shoulder on her way out the door.

Dissociated Elaboration:
She decided to leave behind her customized ice skates that her boyfriend gave her. Dorothy had never taken these skates to the park because she did not want them to be damaged by the uneven ice on the outdoor rink.

Filler:
She trudged through the snow covered streets on her way to the park. She was amazed at how beautiful the trees looked as their branches glistened in the sun. Dorothy noticed that there were quite a few people already enjoying the winter wonderland when she arrived. She spotted some friends who were having fun at the frozen pond. They called Dorothy over to join them.

Dissociated-Consistent/Associated-Inconsistent Critical and Spillover Sentences:
Dorothy wished she had a pair of skates.
She decided to go the rental booth.

Associated-Consistent/Dissociated-Inconsistent Critical and Spillover Sentences:
Dorothy eagerly put on her ice skates.
She tied her laces and went to the rink.

Closing:
She asked the lady at the counter for her size. Dorothy laced up the skates and stepped onto the ice.

Probe:
Skates
task, each of the target objects were used as a probe word (e.g., *skates*) and participants were asked to read this word aloud either immediately following the elaboration section or immediately following the filler section. In addition, they also created a neutral condition in which the target object was mention, but not specifically connected to the protagonist. This allowed for direct comparison between the object availability and the control condition. It was expected that objects would be highly available in all conditions directly following the elaboration section due to semantic priming. However, the critical question is whether object availability would vary across conditions when the probe word was presented after the filler section.

Given the assumption that protagonist-associated objects are held active in memory, any change in their availability from the elaboration section to the filler section should be smaller in the associated condition than in the neutral condition. Conversely, neither protagonist-dissociated objects nor neutral objects should be available after the filler section. Therefore there should be no difference between naming times between these two conditions. Results were mixed. Target words were read more quickly following the elaboration section compared with the filler section across the three conditions. However, there was no significant interaction between elaboration and probe position. This indicated that objects across elaboration condition were less accessible after the filler section. Thus, the privileged status of protagonist-associated objects is fleeting. These results suggest that the larger contradiction effect found in Experiment I were due to differences in the integration (i.e. accessibility) rather than any underlying differences in the object activation levels (i.e., availability).
In a final experiment, Cook et al. sought to decipher these two concepts. They designed an experiment in which they manipulated the degree or importance of the association between protagonist and target object. The protagonist-association was high, low, or neutral. Participants read target sentences that were inconsistent with the situation model. The goal was to answer whether or not this factor would influence the object’s accessibility and integration. If a situation model includes objects associated with the protagonist and only checks the consistency of the critical sentence, the importance of the object should not influence its integration. Therefore reading times for the inconsistent critical sentence should be longer in the high and low conditions than in the neutral condition.

Results showed that reading times for the critical sentence in both high and low associated conditions were longer than in the neutral condition. There was no difference between reading times in the high versus the low associated condition. These results show there is no measurable effect of importance on the integration of the critical sentence. This suggests that readers include protagonist-associated objects in their representation of the text and incoming text is then checked for consistency.

Morrow, Bower and Greenspan (1987) further examined the accessibility of information from situation models is available during comprehension. In a series of experiments they asked subjects to memorize the layout of buildings as well as the objects in each of the rooms. Next they read passages in which a protagonist was introduced and given a reason for going into the building. See sample passage in Table 3. These passages contained either critical “goal sentences” or “path sentences”. Goal sentences described the protagonist making his way through the building from one room
A. Goal Narrative
Wilbur regretted the day he had ever become the head of the research center. He had just found out that the board of directors was coming for a surprise visit the next day. He called all of the employees together in the library and told them the center was a complete mess.

_Closet Blackboard_
He ordered them to start cleaning up the building immediately. He said he wanted the directors to see a spotless, organized center. He told everybody to spread out and clean every room. He made sure the library was being cleaned and then went to supervise the rest. First he walked from the library into the laboratory.

_Microscope Catalogue_
He noticed some technicians sorting papers into piles and told them to be neat. He strode to the storage area and told the workers to stack the crates carefully. Then he walked from the storage area into the wash room.

_Closet Dock_
He was pleased to see the sparkling tile floor since he knew the board of directors was more impressed by cleanliness than by good research. Next he entered the repair shop and snapped at the shop foreman for leaving greasy machine parts laying around. Then he walked from the repair shop into the lounge.

_Counter Computer_
When he ordered the ping pong table removed, he began to feel that he was overreacting to the visit. So he tried to calm down as he went into the experiment room and looked around. Then he walked from the experiment room into the reception room.

_Wilbur Plant_
He thought the flowers his secretary had placed in the room were a nice touch. He went into the office and gathered his notes for the presentation to the board. Then he walked from the office into the conference room.

_B. Path Narrative_
Judy had received several threatening notes in her mailbox at the research center, but she dismissed them as a joke. She was trying to finish up a project so she worked late one night in the laboratory. Her concentration was broken by the sound of a slamming door.

_Mirror Clock_
Then she heard footsteps in the distance. She looked around the laboratory but didn’t see anyone. Suddenly she remembered the threatening notes and became frightened. She decided to see if anyone else was in the building. While she was walking through the storage area toward the wash room, she glanced nervously behind the crates.

_Judy Lifter_

Once in the wash room, she grabbed a paring knife that was by the sink. She gathered her courage and slipped out of the room quietly. While she was walking through the repair shop toward the lounge, she stifled a scream when she slipped on some oil.

_Bed Projector_

Reaching the lounge, she switched on the lights, but no one was there. She switched off the lights as she crept out of the room. As she was walking through the experiment room toward the reception room, she made sure no one was hiding in the booths.

_Rack Radio_

She entered the reception room and noticed the front door was locked. She left the room still feeling frightened. While she was walking through the office toward the conference room, she heard papers rustling.

_Radio Lamp_

When she reached the conference room, she noticed the coffee maker was bubbling. Feeling puzzled, she left the room. While she was walking through the library toward the laboratory, she discovered the new research assistant reading on the couch.

_Lockers Sink_

She quickly went onto the laboratory, feeling very relieved and a little foolish. Then she remembered she had left on the lights in the other rooms so she left the laboratory. While walking through the storage area toward the wash room, she switched off the lights.

_Crates Closet_

She remembered the knife she had slipped in her pocket and felt silly about overreacting so much.
to another; path sentences described the protagonist en route to a goal destination but were not yet there. After each goal sentence they received a probe verification task in which they were given two objects and were asked to indicate if the objects were from the same room. Results for the goal sentences showed that response time was faster when the objects were from the goal room that the protagonist had just reached. Further, as the distance from the goal room increased, response time also increased. This supported a location and distance effect of information accessibility in a situation model. Results for the path sentences showed that response times for objects in the room mentioned, the goal room, as well as rooms that were near the goal room were all equally fast. These results provide strong support for a distance effect. The authors concluded that in goal sentences readers focus on the character’s location, whereas in path sentences, they focus on both the character’s location as well as the intended destination.

O’Brien and Albrecht (1992) further examined the development of a situation model. Specifically, they tested the popular claim that readers will update their situation model to include information relevant to the protagonist (e.g. Black et al., 1979; Bower & Morrow, 1990; Morrow, 1985a, 1985b; Morrow et al., 1990) and further, that they adopt the protagonist’s perspective. See sample passage in Table 4. They designed passages that describe a protagonist in one of two specific locations (e.g., Kim stood inside/outside the health club). In a “close” condition, a second location sentence immediately followed the first, while in a “distant” condition three intervening sentences fall before the second location sentence. In the “consistent” condition the second location sentence describes the protagonist move from her starting location (e.g., She decided to go outside the health club). In the “inconsistent” condition, this second location sentence contradicts the first
Table 4.

Sample passage from O’Brien and Albrecht Experiment 1a and 1b (1992)

As Kim stood (inside/outside) the health club she felt a little sluggish.

Filler:
Workouts always made her feel better. Today she was particularly looking forward to the exercise class because it had been a long, hard day at work. Her boss had just been fired and she had to fill in for him on top of her own work.

Target sentence:
She decided to go outside and stretch her legs a little.

She was getting anxious to start and was glad when she saw the instructor go in the door of the club. Kim really liked her instructor. Her enthusiasm and energy were contagious.
by stating that the protagonist moves to location at which she can already be found.

Results indicated that participants read the critical sentence (second location sentence) more slowly when it was inconsistent. Further, they read this sentence more slowly in the close condition than in the distant condition. These results provide additional support that readers track the protagonist's location in their situation model.

In a second experiment, O'Brien and Albrecht (1992) tested directly the assumption that readers adopt the perspective of the protagonist while reading a text. They developed passages describing a protagonist in one consistent physical location. Next, a second character was described moving in a direction that was either consistent or inconsistent with the protagonist's (e.g., *when she saw the instructor come in the door*). See sample passage in Table 5. For example, when the first sentence describes Kim standing *inside* the health club, the instructor coming in the door is consistent with the protagonist's perspective. In contrast, when the first sentence describes Kim standing *outside* the health club, the instructor is now moving in a direction inconsistent with the protagonist's perspective. If readers adopt the protagonist's perspective they should experience comprehension difficulty as demonstrated by a slow-down in reading time when the text describes a second character moving in a direction inconsistent to the protagonist. Results did not support this claim; there was no difference between reading times between the inconsistent and consistent condition. In a follow-up study, readers did show evidence of disruption when reading the inconsistent sentence however, these participants were specifically instructed to read the passages from the perspective of the protagonist. Therefore it seems that without explicit instructions, the reader will not
As Kim stood (inside/outside) the health club she felt a rush of excitement.

Distant Condition:
Workouts always made her feel better. Today she was particularly looking forward to the exercise class because it had been a long, hard day at work. Her boss had just been fired and she had to fill in for him on top of her own work.

Target sentence:
She was getting anxious to start and was glad when she saw the instructor come in the door of the club.

Kim really liked her instructor. Her enthusiasm and energy were contagious.

Did Kim like her exercise instructor?
automatically take on the perspective of the protagonist for the purpose of his or her representation of the text.

In addition to spatial information situation models may also include information concerning the emotions of discourse characters (Gernsbacher, Goldsmith, & Robertson, 1992; Gernsbacher & Robertson, 1992), goal-relevant information (Huitema et al., 1993), as well as additional information about the protagonist (Glenberg et al., 1987).

Focus Models

The strength of situation models is that they reflect the impact of outside factors on the comprehension process, such as previously integrated text and general world knowledge. However, situation models do not provide a mechanism by which incoming text can be put into the context of what came before. Sanford and Garrod (1981) presented their scenario-mapping and focus (SMF) theory to address how this process occurs. They described two memory structures: a place for implicit information and another for explicit information. Explicit focus generally contains information active in memory about the protagonist, such as objects or places written in the text; while implicit focus contains information from general world knowledge. Explicit focus is necessarily limited by the constraints of WM; however, implicit focus is without such constraints. Implicit focus may contain any related information within LTM.

Sanford and Garrod (1981) suggested that “discourse pointers” link explicit and implicit focus. They describe discourse pointers as elements of the situation model that serve to trigger information no longer in active memory. Their purpose is in continually
guiding the reader to information that they might need. However Cook, Halleran, & O’Brien (1998) concluded that this mechanism was ultimately too powerful. Instead, they found evidence suggesting that related information from memory would influence comprehension.

CHAPTER II
CURRENT MODELS OF READING COMPREHENSION

Construction-Integration Model

Probably the most influential current model of reading comprehension is Kintsch’s (1988) construction-integration (C-I) model. The C-I model is a two-stage process model. In the first stage, (i.e. construction) portions of the text as well as general world knowledge become active in an automatic activation process. The activation process starts with a concept or idea encountered in the text sending out an unrestricted signal to all of memory. This signal is “dumb”, holding that relevant and irrelevant information may be primes. There are four possible sources of activation: the current sentence or proposition, the previous sentence or proposition, general world knowledge, and past text. Any of these sources may send out a signal to all of memory and activate any number of nodes. The second stage, integration occurs when activation spreads to all possible connections until it stops. This results in related concepts receiving more activation that lesser related concepts. Comprehension is limited by what is referred to as “constraint satisfaction”, which means that a concept becomes active based on how
related it is and, therefore only active information from the four sources will affect comprehension. Due to the constraints of WM it is likely that some concepts must be more connected than others.

There is substantial research that supports that concepts become active based on featural overlap (e.g. Cook, et al., 1998; Long & Lea, 2005; O’Brien & Albrecht, 1991). The more features that a node shares in common, the more likely a concept is to become active. O’Brien and Albrecht (1991) wrote passages in which an event was described in either low or high context. See sample passage in Table 6. In the high context version the description given was filled with rich contextual cues supporting an elaborated concept (i.e., in the example passage, “skunk” is the elaborated concept that a reader will likely infer). In contrast, in the low context version, there is less elaboration and fewer cues that suggest the target concept (i.e., “skunk”) leaving room for a reader to infer alternate antecedents (i.e., “cat”). Following a reinstatement sentence, readers were asked to name aloud either the highly elaborated concept or alternative concept.

They predicted that in the high context version, “skunk” would be named faster that “cat”, but that associated concepts like “cat” would be named more quickly than unrelated concepts. This is because associated concepts contain more features in common with the target concept. Further, they predicted that the target concept and associated concept would be read equally fast in the low elaboration version. Their results supported these predictions. In the high context version both target concepts and associated concepts became active.
Mary was driving in the country one day

High context:
when she smelled a terrific odor.

Low Context:
and she gazed at the setting sun as she went.

Suddenly a small black (skunk/cat)

High Context:
with a white stripe down its back

Low Context
with a long furry tail

ran in front of her car. Mary knew she couldn't stop in time. However, she hoped she had managed to miss the animal and continued on her way. After a while, she noticed she was low on gas. While at the gas station, the attendant asked her what had run in front of her car.
Explanation-Based View

In one prominent explanation-based view Graesser, Singer and Trabasso (1994) predict specifically what types of inferences are generated online. They used the concept of “search after meaning” (Bartlett, 1932) and elaborated on the principles underlying this process. They emphasize the point that “search after meaning” is an effort that is not necessarily fulfilled. According to Graesser, Singer and Trabasso (1994) the three principles underlying the “search after meaning” are goal assumption, coherence assumption and explanation assumption. The goal assumption suggests readers address their underlying goals. This is assumed to occur at a deep level of processing. The coherence assumption suggests readers attempt to form a situation model that is both locally and globally coherent. Finally, the explanation assumption suggests readers attempt to explain why actions, events and states are part of the text. There are three types of inferences unique to the constructionist model in that they are thought to be generated on-line. These three types of on-line inferences include superordinate goals, causal antecedents, and global thematic inferences. Further, the following types of inferences are not thought to occur on-line, forecasting future episodes and tracking spatial location of objects. In all cases, these hypotheses only apply assuming the reader is attempting to construct a meaningful situation model, has sufficient background knowledge, and considers the text considerate. Unlike the minimalist hypothesis (McKoon & Ratcliff, 1992) which focuses on whether a given inference category will occur automatically versus strategically, the constructionist view focuses on predicting what inferences will be generated on-line versus off-line.
Event-Indexing Model

The event-indexing model (Zwaan, Langston & Graesser, 1995; Zwaan, Magliano & Graesser, 1995) includes predictions of how the reader will construct a situation model. According to this view, the protagonist’s events and intentional actions are the central focus of situation models. Further, the authors suggest these events and actions are held together along five dimensions: time, space, protagonist, causality, and intentionality.

The time dimension refers to whether or not the incoming text describes a situation that occurs in a same time as the previous sentence; this is referred to as the narrative “now.” Similarly, the spatial dimension refers to whether or not the incoming text describes a situation that occurs in the same spatial setting as the previous sentence; this is referred to as the narrative “here.” A causal dimension refers to whether or not there is a direct causal link between the situation described in the previous sentence and the incoming sentence. The protagonist and intentional dimensions refer to whether or not the incoming sentence is about the same protagonist and whether the overlying goal/motivation remains the same, respectively. An assumption of this model is that the reader will actively track each of these five dimensions. Additionally, when the reader encounters new or incongruent information along any of the five dimensions they will update their representation of the text. According to the event-indexing model readers will always hold a fully up-to-date representation of the text that will be unaffected by outdated information.

A fully up-to-date representation of the text has been largely discredited (e.g. O’Brien, Cook, & Gueraud, 2010; O’Brien, Cook, & Peracchi, 2004). In fact, the field
has gradually moved toward a more memory-based view of comprehension, which I will talk about in the next section.

**Memory-Based View**

In contrast to the event-indexing model and the explanation-based view, the memory-based view of text processing (Myers & O'Brien, 1998; O'Brien & Myers, 1999) does not assume any active search process on the part of the reader. Instead, the memory-based view relies on the influence of backgrounded information on current text processing. When the reader encodes information, a message is sent to all of memory and the concepts that resonate most strongly, return to active memory and may influence comprehension. Ratcliff (1978) used a tuning fork metaphor to describe the resonance process. When struck, the tuning fork will send out waves of a specific frequency to all of memory. Tuning forks, or concepts within memory that share similarities will respond more strongly than others. The tone or memory sharing the most similarities will be selected.

Myers and O'Brien (1998) explained the activation process in their resonance model (see also O'Brien & Myers 1999). The resonance model is similar to the construction phase of the C-I model. In the resonance model, concepts within the current sentence or contents of WM serve as signals sent out to all of memory concurrently. Although the intensity of the signal may be affected by the amount of attention allocated to concepts in focus, signals continue uninterrupted and do not operate under conscious control. The resonance process is dumb, passive and continuous. The concept of
resonance was first proposed in basic models of memory (e.g. Gillund & Shiffrin, 1984; Hintzman, 1986; Ratcliff, 1978). According to this view, relevant information in LTM will become reactivated through a fast-acting, passive process of resonance. Active memory sends a signal to all of memory, and in turn, related concepts will resonate. Concepts receiving sufficient activation will return to active memory.

Once information has been made available (i.e. returned to working memory through resonance), more active strategies may be considered. One such strategy is “standards of coherence” (e.g. van den Broek, Risden & Husebye-Hatman, 1995). These standards describe a reader’s motivation when the resonance process fails to provide the information necessary to establish coherence. The higher the reader’s standard of coherence, the more connections they will attempt to make. If they encounter something they do not understand in the text they might continue reading or wait for relevant information in memory to fill in the gaps and achieve comprehension. A reader with a high standard of coherence is more likely to wait for the necessary information in memory to become active before continuing to the next sentence. This would result in a slow down in reading time reflecting a high degree of processing.

A useful protocol used to assess the availability and influence of information during comprehension is the contradiction paradigm (Albrecht & O'Brien, 1993; Cook, Halleran, & O'Brien, 1998; O'Brien & Albrecht, 1992; O'Brien, Rizzella, Albrecht, & Halleran, 1998). The contradiction paradigm was developed in the context of the memory-based view of reading comprehension and can be used to assess directly the extent to which information from earlier has become available. In this paradigm, participants read passages containing information in a target sentence that conflicts with
information in LTM. If the conflicting information becomes active and the reader attempts to resolve the conflict, then it should disrupt comprehension and inflate the time to read the target sentence. Reading time provides a reliable assessment of the degree of difficulty integrating information into memory; therefore, it provides an excellent measure of contributions of general world knowledge to moment-by-moment comprehension.

**Maintaining global and local coherence**

Constructing a situation model requires drawing inferences to accomplish comprehension. One of the initial distinctions between explanation-based and memory-based models of processing was the degree to which they emphasized global coherence. We now know that a fully coherent text will maintain both local and global coherence. *Local coherence* involves connecting currently processed information with the immediately preceding context (information that is in short-term memory (STM), generally the previous 1-3 sentences). *Global coherence* involves establishing connections between the currently processed information and information that occurred much earlier in the text that is no longer in STM but is relevant. Previously, it was thought that global coherence was accessed only when there was a break in local coherence or if the information was readily accessible (McKoon & Ratcliff, 1992). On the basis of further examination, it is now well accepted that readers attempt to maintain both local and global coherence at all times.

For example, Albrecht and Obrien (1993) demonstrated that readers were disrupted when they reached a global coherence break even when the text was locally
coherent. See sample passage in Table 7. Participants read passages in which a character was introduced and described then backgrounded. Next, a critical sentence was presented that was either globally consistent or globally inconsistent with the protagonist’s characteristics. Reading times showed evidence of disruption (slower reading times) when the text was globally inconsistent even though they were always locally consistent. They also found that memory for the regions of text involving the inconsistencies was improved. This is consistent with predictions by O’Brien and Myers (1985) that when readers experience comprehension difficulty that can be resolved, there will be a memory benefit for information pertaining to the inconsistency.

O’Brien, Rizzella, Albrecht, and Halleran (1998) altered materials from Albrecht and O’Brien (1993) by adding a qualified condition in which certain conditions were described under which the target characteristic would or would not apply to the protagonist. See sample passage in Table 8. Results indicated that readers still experienced comprehension difficulty in the qualified condition when the target action was fully operative. These results provide support for resonance as unrestricted and dumb. Additionally, results showed readers use general world knowledge to maintain a globally coherent representation of protagonist.

Further support for a memory-based view comes from Cook, Halleran, and O’Brien (1998). Participants read passages in which a protagonist engaged in an action that would be considered inconsistent with the description given for a secondary character. That is, the passage introduced the protagonist’s friend and elaborated on a
Table 7.

Sample passage from Albrecht and O'Brien (1993)

Introduction:
Today, Mary was meeting a friend for lunch. She arrived early at the restaurant and decided to get a table. After she sat down, she started looking at the menu.

Consistent Elaboration:
This was Mary's favorite restaurant because it had fantastic junk food. Mary enjoyed eating anything that was quick and easy to fix. In fact, she ate at McDonalds at least three times a week. Mary never worried about her diet and saw no reason to eat nutritious foods.

Inconsistent Elaboration:
This was Mary's favorite restaurant because it had fantastic health food. Mary, a health nut, had been a strict vegetarian for 10 years. Her favorite food was cauliflower. Mary was so serious about her diet that she refused to eat anything that was fried or cooked in grease.

Neutral Elaboration:
This was Mary's favorite restaurant because it has a nice quiet atmosphere. Mary frequently ate at the restaurant and had recommended it to all of her friends. She especially liked the cute tables and the country style cloths on them. It made her feel right at home.

Filler:
After about 10 minutes, Mary's friend Joan arrived. It had been a few months since they had seen each other. Because of this Mary and Joan had a lot to talk about and chatted for over a half hour. Finally, the signaled the waiter to come take their orders. They checked the menu one more time. Mary and Joan had a hard time deciding what to have for lunch.

Critical Sentences:
Mary ordered a cheeseburger and fries.
She handed the menu back to the waiter.

Closing:
Her friend didn't have as much trouble deciding what she wanted. She ordered and they began to chat. They didn't realize there was so much for them to catch up on.
Table 8.


Introduction:
Today, Mary was meeting a friend for lunch. She arrived early at the restaurant and decided to get a table. After she sat down, she started looking at the menu.

Consistent elaboration:
This was Mary’s favorite restaurant because it had fantastic junk food. Mary enjoyed eating anything that was quick and easy to fix. In fact, she ate at McDonald’s at least three times a week. Mary never worried about her diet and saw no reason to eat nutritious foods.

Inconsistent elaboration:
This was Mary’s favorite restaurant because it had fantastic health food. Mary, a health nut, had been a strict vegetarian for ten years. Her favorite food was cauliflower. Mary was so serious about her diet that she refused to eat anything which was fried or cooked in grease.

Qualified elaboration:
As she was waiting, Mary recalled that this had been her favorite restaurant because it had fantastic health food. Mary recalled that she had been a health nut and a strict vegetarian for about ten years but she wasn’t anymore. Back then, her favorite food had been cauliflower. At that time, Mary had been so serious about her diet that she had refused to eat anything which was fried or cooked in grease.

Filler:
After about ten minutes, Mary’s friend arrived. It had been a few months since they had seen each other. Because of this they had a lot to talk about and chatted for over a half hour. Finally, Mary signaled the waiter to come take their orders. Mary checked the menu one more time. She had a hard time deciding what to have for lunch.

Target sentence 1:
Mary ordered a cheeseburger and fries.

Target sentence 2:
She handed the menu back to the waiter.

Closing:
Her friend didn’t have as much trouble deciding what she wanted. She ordered, and they began to chat again. They didn’t realize there was so much for them to catch up on.
critical characteristic (e.g., Mary’s friend Joan is a vegetarian). By rewriting the elaboration sections from O’Brien et al. (1998) to describe the secondary character they were able to test directly the premise that resonance is unrestricted. Reading time on the target sentence (e.g., Mary ordered a cheeseburger and fries) were not slowed, indicating that readers were not disrupted by the information about the secondary character; however, a subsequent probe study revealed that characteristics of the secondary character became reactivated following the target sentence. This is consistent with an unrestricted reactivation process in which concepts (e.g. vegetarianism) will become active based on their degree of featural overlap (i.e. the characters’ eating habits). This study also demonstrates that relevance does not determine what information will influence the reactivation process. Activation based upon featural overlap can be described as activation based not on relevance but rather on “relatedness”.

Perhaps the most convincing evidence that related but outdated information continues to influence activation comes from O’Brien, Cook, and Gueraud (2010). In O’Brien et al. passages describe a critical character or object undergoing an irreversible change-in-state (e.g., a tree is cut down). See sample passage in Table 9. The passages contain information that is either consistent, inconsistent, or qualified with respect to a target sentence (e.g., All that remained of the tree was a stump). The critical qualified condition, a tree is described, a decision is made that it will not be cut down, but then the tree was struck by lightning and must be cut down. In this condition, the outdated information (e.g., the characters decided not to cut down the tree) is paired with an irreversible change of state. Although the outdated information was rendered inconsequential, readers still showed signs of disruption; the target sentence was read
Sample passage from O’Brien, Cook, and Gueraud (2010)

Introduction:
Susan was writing her first novel from her study at home.

Consistent condition:
Her study was on the second floor and she had a beautiful view from one of the widows facing the backyard. She loved to sit and think about what she wanted to write while looking out the window at a graceful old oak tree. When her husband wanted to cut it down she reluctantly agreed with him. They both thought it was a tragedy that such a beautiful tree had to be taken down. Still, they had it cut down and removed.

Inconsistent condition:
Her study was on the second floor and she had a beautiful view from one of the widows facing the backyard. She loved to sit and think about what she wanted to write while looking out the window at a graceful old oak tree. Once her husband wanted to cut it down but she stopped him. She thought it would be a tragedy if such a beautiful tree were taken down. He agreed and decided not to have it cut down and removed.

Qualified condition:
Her study was on the second floor and she had a beautiful view from one of the widows facing the backyard. She loved to sit and think about what she wanted to write while looking out the window at a graceful old oak tree. Once her husband wanted to cut it down but she stopped him. She thought it would be a tragedy if such a beautiful tree were taken down. He agreed and decided not to have it cut down and removed. Soon afterwards, however, the tree was struck by lightning and had to be cut down.

Filler:
Susan really wanted to focus on working on her novel. She had already outlined the plot and developed her characters. Today, though, she was suffering from a bad case of writer’s block. She just could not decide what she wanted to write next. While she was thinking, she got up and went over to look out the window.

Target sentence 1:
All that remained of the tree was a stump.

Target sentence 2:
Susan missed seeing the tree in her yard.

Closing:
She decided to plant a new tree in the same spot in the spring.
more slowly in the qualified condition than the consistent condition. Because the outdated information was related, it became reactivated through a passive resonance process. This information then continued to affect processing.

Related information has the potential to be disruptive to this mechanism. For example if the reader encounters information that conflicts with information already in memory, this will cause comprehension difficulty. Given what the reader already knows, conflicting information cannot be correct. However, a second way related information could be disruptive is if a reader is confronted with conflicting information that is actually correct. In this scenario the reader has previously learned incorrect information (i.e. misconception) and then encounters text correcting this incorrect information. The hope would be that this text will correct the misconception.
CHAPTER III
THE ROLE OF UPDATING

The purpose of the proposed research is to investigate the underlying cognitive processes that support individual belief revision in college students in the context of text. The long-range goal is to improve learning specifically from science texts through the development and evaluation of interventions that address the underlying causes of students' learning failures. In order to more fully understand individual belief revision, I will begin with common misconceptions that span several areas to assess the impact of texts that contain refutations and explanations on the ability of individuals to revise their misconceptions.

Learning science often involves the revision of prior knowledge at the level of systems (structural changes), at the level of individual concepts, and at the level of individual beliefs (Smith, diSessa, & Roschelle, 1993; Vosniadou, Vamvakoussi, & Skopeliti, 2008). This type of learning is known as conceptual change. Conceptual change is required in science learning because scientific concepts and theories are the products of scientific revolutions that took our culture hundreds of years to accomplish and therefore are usually counter-intuitive, contradicting basic commonsense beliefs constructed on the basis of everyday experience (Carey, 1985; 2009; Chi, 2008). Scientific concepts consist of interrelated networks of beliefs and often many of these beliefs need to change, in addition to changes at the structural level (diSessa, 2008; Carey, 1985; Vosniadou et al., 2008). In the present study I focus on change at the individual belief level in college students.
A great deal of science learning is accomplished or supplemented through the use of texts. However, research has shown that science texts are difficult for students to understand; their most severe limitation being their failure to affect knowledge revision (Goldman & Bisanz, 2002; Graesser, Leon, & Otero, 2002). Indeed, in a recent series of studies Vosniadou and Skopeliti (submitted) have documented students’ widespread comprehension failures and inferential errors when reading texts in which a scientific explanation was incompatible with their prior knowledge.

Even though science texts are often difficult for students to understand, Refutation text is a type of text that is designed to persuade students to change their commonsense beliefs through direct contradiction of that belief and a presentation of the scientifically-correct belief (Guzzetti, 1990; Hynd & Guzzetti, 1998). Indeed, refutation texts have been shown to effectively promote belief revision (Guzzetti et al., 1993). However, much of the actual cognitive “work” that produces belief revision takes place during encoding processes, that is, when the refutation text is read and integrated into memory. Very little is currently known about these processes (Kendeou & van den Broek, 2007).

Research in individual belief revision spans several disciplines (cognitive science, science education, conceptual change learning, reading comprehension). The majority of the research has focused on belief revision in science therefore we draw most of the evidence from such research. However, it is likely that the implications of such research have a more global reach. Five major principles in the science informed the proposed research.

Principle 1: Knowledge revision in science is particularly necessary given that students often come to school with intuitive or commonsense beliefs about how the
world works which are different from those of currently accepted science. Since the late 1970s, science educators (e.g., Clement, 1987; 1988; 1989a; 1989b; Driver & Easley, 1978; McCloskey, 1982; Posner et al., 1982; Viennot, 1979) have been aware that students did not arrive in science class with a “tabula rasa” when it came to learning about their world. Rather, they arrived with alternative frameworks, preconceptions, commonsense beliefs or misconceptions that prove difficult to reverse and often serve to impede successful learning. Cognitive developmental research shows young children, not yet exposed to formal science, answer questions about force, matter, heat, the day/night cycle etc. in a manner that reveals their commonsense conceptions that differ from the explanations they will learn through formal science education (Baillargeon, 1995; Carey & Spelke, 1994; Gelman, 1990; Ioannides & Vosniadou, 2002; Vosniadou & Brewer, 1992; 1994; Wiser & Smith, 2008). Over time, research has demonstrated that these early commonsense beliefs need to be considered in designing effective instruction (Clement, 1993).

**Principle 2: Knowledge revision is an incremental process.** Knowledge revision (or conceptual change) is likely to occur in slow steps or increments of different grain sizes of knowledge representation (Vosniadou, 2008). Although there is no well-accepted model of knowledge representation, one reasonable framework suggests that knowledge consists of concepts, and concepts consist of interrelated networks of individual beliefs. Maintaining a bottom-up approach, the focus of these experiments is on the revision of the individual belief level. At this level, oftentimes multiple interrelated beliefs are in need of change, in addition to changes at the structural level (diSessa, 2008; Carey, 1985;
Each individual belief revision contributes to the incremental process that ultimately leads to concept revision (Chi, 2008).

**Principle 3:** Belief revision in science can be accomplished in the context of text-based learning. A great deal of science learning is accomplished through text-based materials. Over the past decade, research has demonstrated that refutation texts, texts that state a commonsense belief and explicitly refute it while providing the scientific belief (Alvermann & Hauge, 1989; Chambliss, 2002; Guzzetti et al., 1993; Guzzetti, 2000) can serve as an effective tool of individual belief revision for students at elementary, secondary, and college level (Alvermann & Hague, 1989; Alvermann & Hynd, 1988; Anderson & Smith, 1986; Diakidoy & Kendeou, 2001; Diakidoy, Kendeou & Ioannides, 2003; Guzzetti, Williams, Skeels & Wu, 1997; Hynd & Alvermann, 1986a; 1986b; Lipson, 1982; Maria & Johnson, 1989; Maria & MacGinitie, 1987). Maintaining this principle, the proposed experiment will investigate belief revision in commonly held misconceptions in the context of systematic textual manipulations. Specifically we a) refute commonsense beliefs, b) refute commonsense beliefs and explain why they are incorrect, and c) refute commonsense beliefs, explain why they are incorrect, and provide the correct belief.

**Principle 4:** To understand individual belief revision in the context of text-based learning, it is important to gain a thorough understanding of both the processes in which students engage and the outcome, or product of such processes. Based on cognitive psychological theories, text-based learning occurs through a process of constructing a situation model in which distinct elements of the text are linked and integrated with the reader's related prior knowledge through inferential and other
cognitive processes. Those processes that occur online make up the foundation for constructing a mental representation or situation model based on the text (Goldman & Varma, 1995; Kintsch, 1988; Langston & Trabasso, 1999; Myers & O’Brien, 1998; van den Broek, Young, Tzeng & Linderholm, 1999). Conclusions made about online comprehension processes should then be consistent with observations based on the end result of reading, and vice-versa. The online measure for the proposed experiments is sentence-by-sentence reading times.

*Principle 5: A necessary condition for individual belief revision is the co-activation of correct and incorrect knowledge.* Simultaneous activation of commonsense misconceptions and correct beliefs, is a necessary step toward belief revision (Kendeou & van den Broek, 2007; Kendeou, Muis & Fulton, in press; van den Broek & Kendeou, 2008). Allowing for the reader to detect inconsistency, co-activation facilitates additional processing in an attempt to establish coherence (Glenberg, Wilkinson & Epstein, 1982; Graesser, et al., 1994; McNamara & Kintsch, 1996) or reconcile the inconsistent information (e.g., Hakala & O’Brien, 1995). This principle is demonstrated in the proposed research by way of the contradiction paradigm (Albrecht & O’Brien, 1993; Cook et al., 1998; O’Brien & Albrecht, 1992; O’Brien et al., 1998) to measure directly the extent to which explicit refutations make contact with commonsense beliefs in long-term memory.

Consider how this paradigm can be used to provide insight into the moment-by-moment cognitive processes invoked by refutation texts. A commonsense belief is that ostriches bury their heads to hide from their enemies (Maria & MacGinitie, 1987). Individuals identified to have this commonsense belief could read a text about ostriches
in one of two versions. In one version, a refutation sentence would be included that explains that ostriches do not bury their heads. This version would then explain that ostriches dig large holes in the ground for their eggs and when they bend down to turn the eggs, they often appear to be burying their heads in the sand. In a control version, the refutation would be replaced by a non-refutation and non-explanation that would continue the story but fail to address the incorrect belief. Next, a target sentence would be presented that describes that ostriches do not bury their heads in the sand. If the reader has successfully integrated the refutation and changed the commonsense belief, then reading time on the target sentence should be slowed; prior knowledge now conflicts with the idea that ostriches bury their heads. In contrast, if the reader did not successfully integrate the refutation, then prior knowledge would still be consistent with the idea that ostriches bury their heads; reading times on the target sentence would not be slowed.
CHAPTER IV

EXPERIMENTS

The goal of the present thesis was to explore the underlying cognitive processes that support individual belief revision. Consider the first experimental passage in Appendix C. Individuals who hold a misconception (e.g., *seasons are caused by the Earth being closer to the Sun in the summer than in the winter*), read a passage that either addressed the misconception or failed to address it as incorrect. Within the current framework, a reader who has successfully revised their misconception would be expected to read the correct outcome (e.g., *the tilt of the Earth causes the seasons*) quickly; however, if they failed to revise their belief, they would be expected to be disrupted and show a slowdown in reading time. We predicted that only individuals that read both a refutation and explanation would be able to successfully revise their belief. The following experiments utilized common misconceptions that spanned several areas to assess the impact of text that contained refutations and explanations on the ability of individuals to revise their misconceptions.

In the present experiments the amount of relevant information pertaining to a misconception was systematically manipulated to assess the impact of text refuting a misconception and text explaining the correct information. Experiment I assessed the impact of the refutation. Participants read either a refutation or a non-refutation version of the passage. Experiment II assessed the joint impact of the refutation and the explanation. In this experiment, participants read a refutation and explanation or a non-refutation and
non-explanation. Finally, Experiment III assessed the effect of the explanation. In this experiment, participants read only the explanation or non-explanation.

**Experiment I.**

In Experiment I participants read passages that contained either a refutation section or a non-refutation section. Consider the sample passage for Experiment I. in Table 10. In this passage Jack and Ryan questioned why it was so hot in the summer and cold in the winter. In the refutation condition Ryan stated his belief that the Earth was closer to the Sun in the summer and this caused the difference in temperature between seasons. In this condition, the boys' mother informed Ryan that his belief was incorrect. Next, the reader was given a correct outcome sentence that provided the truth behind the misconception. In this case, the mother stated that the tilt of the Earth causes the seasons. This information alone is unlikely to provide sufficient information in memory to cause the reader to successfully revise their belief.

**Method**

**Participants**

The participants were 36 per study from the University of New Hampshire. Participants received course credit for their participation in the experiment.

**Materials**

The materials included a true/false inventory including forty facts (20 true and 20 false) that was completed by all participants. The materials also included 10 passages. Each passage began with a ten sentence introductory section that was 100 words. After the introduction were three sentences that composed either a refutation or non-refutation
Sample passage for Experiment I.

Misconception
Seasons are caused by the Earth being closer to the Sun in the summer than in the winter.

Introduction
The Parker family was vacationing at their favorite spot at a scenic New England lake. Every summer they would rent the same cabin right on the water. The two brothers, Danny and Ryan especially enjoyed the lake for water skiing and tubing. It was an exceptionally hot day so the boys decided to gear up for some water skiing. Danny had trouble adjusting his life jacket because his hands were dripping with sweat. Frustrated, he asked his brother why it was always so hot in the summer and always so cold in the winter. Mrs. Parker overheard her boys talking.

Refutation
Ryan said that he thought it was because the Earth is closer to the Sun in the summer than in the winter. However, Mrs. Parker interrupted and said that this idea was incorrect. She explained to the boys that

Non-Refutation
She said this was just the sort of thing that the boys should look up on the Internet later. Both of the sons agreed that they would look it up on the computer. When they did, they discovered that

Correct Outcome
the tilt of the Earth causes the seasons.

Spillover Sentence
The boys were pleased with their answer.

Closing
They finished getting ready and climbed onto the back of the boat. They spent most of the afternoon water skiing until the sun went down and the temperature cooled off.
that was 39 words. In these sections the protagonist expressed a misconception and was then told the misconception was untrue (refutation) or not (non-refutation). After the refutation or non-refutation section all participants read a correct outcome sentence that stated the correct belief, and a spillover sentence to capture any spillover effect from the correct outcome sentence. Correct outcome sentences and spillover sentences were 40-42 characters. Finally, all passages concluded with a two sentence closing that served to wrap up the storyline. Closing sections were 30 words. At the end of each passage the participants were given a “yes” or “no” comprehension question to make sure they were reading carefully. Two material sets of the same 10 passages were created. Each passage was presented in each condition (refutation or non-refutation) once.

Procedure

All participants were run individually in a session lasting approximately forty-five minutes. Each participant first completed the true/false inventory. Participants were randomly assigned to one of two material sets for the passages. All passages were presented on a video monitor controlled by a Dell 386 microcomputer.

After completing the true/false inventory participants were instructed to rest their right thumbs on a line-advance key, their right index fingers on a “yes” key, and their left index fingers on a “no” key. Each trial began with the word “READY” in the center of the screen. When participants were ready to read a passage, they pressed the line-advance key. Each press of the key erased the current line of text and presented the next line of text. Comprehension time was measured as the time between key presses. Participants were instructed to read at a normal and comfortable reading rate. Following the last line of each passage, the cue “QUESTIONS” appeared in the center of the screen for 2000
milliseconds. This was followed by the comprehension question to which participants responded by either pressing the “yes” or “no” key. On the trials where participants made an error, the word “ERROR” appeared in the middle of the screen for 750 milliseconds.

Before beginning the experimental passages, participants read three practice passages to ensure that they were familiarized with and understood the procedure.

Results and Discussion

The reading times for the correct outcome sentences were recorded. Reading times that were greater than 2.5 standard deviations from the mean were discarded. This resulted in the loss of less than 3% of data. In all experiments reported, $F_1$ refers to tests against an error-term based on participant variability and $F_2$ refers to tests against an error-term based on item variability. All analyses reported are significant at the .05 alpha level unless otherwise indicated.

The mean reading times of the correct outcome sentences in Experiment I are presented in Table 11. Two sets of means will be presented for the correct outcome sentence. The first set of means is for all participants. The second set of means is for only those participants who were scored as having eight or more out of ten misconceptions on the true/false inventory (referred to as the eight-plus group). The correct refutation was read more quickly when it followed the refutation section than when it followed the non-refutation condition. $F_1 (1, 34) = 13.6, MSe = 60,621; F_2 (1,8) = 11.96, MSe = 23,332$.

This result was also true in the eight-plus group. $F_1 (1, 13) = 25.45, MSe = 30,306$

The slowdown in reading times for the non-refutation condition is consistent with a memory-based view. When readers encountered information in the correct outcome
Table 11.

Mean Reading Times as a Function of Refutation in Experiment I.

<table>
<thead>
<tr>
<th>Group</th>
<th>Refutation</th>
<th>Non Refutation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Participants</td>
<td>1797</td>
<td>2011</td>
</tr>
<tr>
<td>8+ Participants</td>
<td>1817</td>
<td>2138</td>
</tr>
</tbody>
</table>
sentence that was inconsistent with information stored in long-term memory regarding the target misconception, they experienced disruption.

**Experiment II**

In Experiment I, a refutation was enough to significantly reduce disruption when readers were presented with the correct outcome sentence. In the second experiment the reader was given a refutation and explanation or a non-refutation and non-explanation. Consider the sample passage for Experiment II in Table 12. In the consistent condition Danny and Ryan’s mother refuted Ryan’s claim, and then in the explanation section, explained the scientific reason for the change in seasons. This was followed by the correct outcome sentence. According to a memory-based perspective, the explanation section should provide more information to integrate into the situation model and an increased likelihood of that information to then compete with previous networks related to the incorrect information. If correct, the facilitation in reading time for the correct outcome sentence should be significantly enhanced.

**Method**

**Participants**

The participants were 36 per study from the University of New Hampshire. Participants received course credit for their participation in the experiment.

**Materials**

The same materials were used from Experiment I with a few small changes. The refutation and non-refutation sections were two sentences and 33 words. After the refutation section was an explanation section and after the non-refutation was a non-
Table 12.
Sample passage for Experiment II.

**Misconception**
Seasons are caused by the Earth being closer to the Sun in the summer than in the winter.

**Introduction**
The Parker family was vacationing at their favorite spot at a scenic New England lake. Every summer they would rent the same cabin right on the water. The two brothers, Danny and Ryan especially enjoyed the lake for water skiing and tubing. It was an exceptionally hot day so the boys decided to gear up for some water skiing. Danny had trouble adjusting his life jacket because his hands were dripping with sweat. Frustrated, he asked his brother why it was always so hot in the summer and always so cold in the winter. Mrs. Parker overheard her boys talking.

**Refutation**
Ryan said that he thought it was because the Earth is closer to the Sun in the summer than in the winter. However, Mrs. Parker interrupted and said that this idea was incorrect.

**Non-Refutation**
She said this was just the sort of thing that the boys should look up on the Internet later. Both of the sons agreed that they would look it up on the computer.

**Explanation**
She explained that the Earth is actually farther away from the Sun when it is summer in the Northern Hemisphere than when it is winter. Seasons are caused by the Earth being tilted on its axis. As the Earth orbits the Sun, different parts of the world receive different amounts of direct sunlight. Even though the Sun is farther away during summer, the Northern Hemisphere is tilted towards the Sun, causing longer days and more direct sunlight. In the winter, even though the Sun is closer, the Earth is tilted away from the Sun. So Mrs. Parker explained again that

**Non-Explanation**
Mrs. Parker was always encouraging her boys to find out the answers to questions they had. She thought this was a good way to teach them because if they had to find the answers themselves, they would remember them better. Sometimes Danny and Ryan found this annoying. They would ask their mom what a certain word meant and rather than just tell them, they had to stop what they were doing and go find the dictionary. They knew there was no point in asking her because their mom was not going to give them the answer. The first place they looked indicated that

**Correct Outcome**
the tilt of the Earth causes the seasons.

**Spillover Sentence**
The boys were pleased with their answer.

**Closing**
They finished getting ready and climbed onto the back of the boat. They spent most of the afternoon water skiing until the sun went down and the temperature cooled off.
explanation section. The refutation and non-refutation sections were shortened to eliminate overlapping information present in the added sections. The explanation section provided a detailed account of the correct information associated with the misconception (i.e. correct belief). The non-explanation section continued the story but failed to address or acknowledge the misconception. The explanation and non-explanation sections consisted of six sentences and 100 words.

Procedure

The procedure was the same as Experiment I.

Results and Discussion

The reading times for the correct outcome sentences were recorded. Reading times that were greater than 2.5 standard deviations from the mean were discarded. This resulted in the loss of less than 1% of data.

The mean reading times of the correct outcome sentences in Experiment II are presented in Table 13. The correct outcome sentence was read more quickly when it followed the refutation and explanation than when it followed the non-refutation and non-explanation. $F_1 (1,34) = 69.52, MSe = 91,120; F_2 (1,8) = 22.68, MSe = 75,033$. The same results were found in the eight-plus group. $F_1 (1, 15) = 22.99, MSe = 108,340$.

The results of Experiment II provided evidence that the refutation in combination with the explanation provided the reader with more information to combat their incorrect belief.
Table 13.

Mean Reading Times as a Function of Refutation & Explanation Type in Experiment II

<table>
<thead>
<tr>
<th>Group</th>
<th>Refutation &amp; Explanation</th>
<th>Non Refutation &amp; Non-Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Participants</td>
<td>1672</td>
<td>2265</td>
</tr>
<tr>
<td>8+ Participants</td>
<td>1789</td>
<td>2447</td>
</tr>
</tbody>
</table>
Experiment III.

In Experiment I, a refutation was enough to eliminate disruption when readers were presented with the correct outcome sentence. In the second experiment the reader was given a refutation and explanation or a non-refutation and non-explanation and the effect grew stronger. The strength of this effect may be carried by the combination of the refutation and explanation or by the explanation section alone. In Experiment III we explored this question further by using the explanation or non-explanation section with no refutation/non-refutation. Consider the sample passage for Experiment III in Table 14. In the consistent condition Danny and Ryan’s mother explained the scientific reason for the change in seasons but never explicitly refuted his belief. Again, this was followed by the correct outcome sentence. In contrast to the refutation section, the content of the explanation section was richer and more abundant. It would not be surprising if this information alone were enough to elicit a powerful effect in reading time.

Methods

Participants

The participants were 36 per study from the University of New Hampshire. Participants received course credit for their participation in the experiment.

Materials

The same materials were used from the previous experiments with one modification. The refutation and non-refutation sections were eliminated.

Procedure

The procedure was the same as Experiment I and II.
Table 14.

Sample Passage for Experiment III.

Misconception
Seasons are caused by the Earth being closer to the Sun in the summer than in the winter.

Introduction
The Parker family was vacationing at their favorite spot at a scenic New England lake. Every summer they would rent the same cabin right on the water. The two brothers, Danny and Ryan especially enjoyed the lake for water skiing and tubing. It was an exceptionally hot day so the boys decided to gear up for some water skiing. Danny had trouble adjusting his life jacket because his hands were dripping with sweat. Frustrated, he asked his brother why it was always so hot in the summer and always so cold in the winter. Mrs. Parker overheard her boys talking.

Explanation
She explained that the Earth is actually farther away from the Sun when it is summer in the Northern Hemisphere than when it is winter. Seasons are caused by the Earth being tilted on its axis. As the Earth orbits the Sun, different parts of the world receive different amounts of direct sunlight. Even though the Sun is farther away during summer, the Northern Hemisphere is tilted towards the Sun, causing longer days and more direct sunlight. In the winter, even though the Sun is closer, the Earth is tilted away from the Sun. So Mrs. Parker explained again that

Non-Explanation
She was always encouraging her boys to find out the answers to any questions they had. She thought this was a good way to teach them because if they had to find the answers themselves, they would remember them better. Sometimes Jack and Ryan found this annoying. They would ask their mom what a certain word meant and rather than just tell them, they had to stop what they were doing and go find the dictionary. They knew there was no point in asking her because their mom was not going to give them the answer. The first place they looked indicated that

Correct Outcome
the tilt of the Earth causes the seasons.

Spillover Sentence
The boys were pleased with their answer.

Closing
They finished getting ready and climbed onto the back of the boat. They spent most of the afternoon water skiing until the sun went down and the temperature cooled off.
Results and Discussion

The reading times for the correct outcome sentences were recorded. Reading times that were greater than 2.5 standard deviations from the mean were discarded. This resulted in the loss of less than 1% of data.

The mean reading times of the correct outcomes sentences in Experiment III are presented in Table 15. The correct outcome sentence was read more quickly when it followed the explanation section than when it followed the non-explanation section. $F_1 (1,34) = 37.48, MSe = 114,820; F_2 (1,8) = 28.68, MSe = 51,586$. The effect was also seen in the eight-plus group. $F_1 (1,14) = 13.77, MSe = 175,638$. Thus, it appears that the effect was being carried almost exclusively by the explanation section. Further discussion will be postponed until the general discussion.
Table 15.

**Mean Reading Times as a Function of Explanation Type in Experiment III**

<table>
<thead>
<tr>
<th>Group</th>
<th>Explanation</th>
<th>Non-Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Participants</td>
<td>1670</td>
<td>2159</td>
</tr>
<tr>
<td>8+ Participants</td>
<td>1710</td>
<td>2340</td>
</tr>
</tbody>
</table>
CHAPTER V

GENERAL DISCUSSION

The goal of the experiments in this thesis was to begin examining the effect of specific refutation texts on belief revision. As defined earlier, a Refutation text is a type of text that is designed to persuade students to change their commonsense beliefs through direct contradiction of that belief and a presentation of the scientifically-correct belief (Guzzetti, 1990; Hynd & Guzzetti, 1998). Faster reading times on a correct outcome sentence when it was paired with a refutation, explanation, or both suggests individuals were not disrupted when reading information that was inconsistent with their belief (i.e. the misconception). While a facilitation in reading time does not in and of itself, indicate that an individual engaged in knowledge revision (i.e. updated their incorrect belief), it does suggest that the individual has begun to represent information contrary to their misconception within the episodic memory trace of the passages they read.

Experiment I demonstrated that providing a refutation section that explicitly negated the misconception was sufficient to significantly reduce disruption when reading a sentence that contained the correct information. In Experiment II an explanation was provided for the refutation section. When the explanation was provided, the effect of the refutation was significantly more pronounced: In Experiment I the refutation facilitated reading times on a correct outcome sentence by 214 ms; In Experiment II when an explanation was included, this facilitation was increased to 593 ms. Experiment III was
designed to assess the impact of that explanation when the refutation was not presented. Results from this experiment provided a very close replication of effects found in Experiment II in which the refutation was included.

That the explanation alone was sufficient to produce just as much facilitation makes sense for the following reasons. First, the explanation section contained an abundance of information that refuted the misconception. Next, contained within the explanation was almost an implicit refutation; thus, adding the refutation above and beyond this would be unlikely to add a greater benefit.

It is important to note that reading times provided evidence that readers were clearly aware of the inconsistency between the misconception and the correct belief. However, this might only have been the result of the reader’s episodic memory trace of the passage and would not necessarily signify any belief change within LTM.

The current set of experiments demonstrate that refutation texts are certainly effective in making readers aware of inconsistencies between their incorrect knowledge (i.e. misconception) and correct information. However, any evidence that this awareness resulted in any long-term belief revision requires long-term research in which LTM performance is assessed both before and after reading refutation texts.

To the extent that reading times serve as an approximation of the impact of refutation text on belief revision, a few interesting patterns begin to emerge. First, a simple refutation provided reliable facilitation but a small effect. This suggests the long-term benefit might be small or not evident. This would be important within the area of refutation texts where the assumption has been that the power of these texts is contained
in the refutation itself. The current set of results indicates that the effect in the refutation is rather small.

The combine results of Experiments II and III suggest that the major impact of refutation texts lies in the explanation, rather than in the refutation itself. This result makes sense given that the explanation contains a rich elaboration filled with information that when represented in memory, begins to form a network competing with that of the original misconception. This new network would begin to interfere with the prior.

The same pattern of results was found in the eight-plus group of participants. However, these participants tended to show a somewhat larger disruption in the non-refutation, non-explanation, and non-refutation plus non-explanation conditions than did the full sample. This finding provides additional evidence that providing to the reader an explanation that corrected the misconception has strong effects, at least in the immediate context. However, any difference between the eight-plus group and the full sample must be viewed with caution. The test administered to assess whether or not participants held a misconception was a simple true-false test. Thus, it is likely that many of the participants that did not fall in the eight-plus group did so because they guessed correctly on the true-false test. That is, many participants had more misconceptions than the true-false test indicated. The pattern of results found among all participants indicated that those who were not provided with a refutation or explanation were in fact, disrupted when reading the correct outcome sentence. This finding lies in contrast to what we would expect to find from a participant with a correct belief. If a participant did not hold a misconception they would be expected to show no evidence of disruption when reading the correct outcome sentence. The correct outcome sentence is consistent with information held in
memory concerning the correct belief. The fact that participants assessed as having less than eight misconceptions were disrupted on a correct outcome sentence when not given a refutation or explanation, also suggests that the target misconceptions were held by more than those indicated by the true-false inventory. What became clear in further studies was that a test will need to be developed that provides a valid and reliable assessment of whether an individual holds a misconception.

The current work maps nicely onto previous work done with the contradiction paradigm (Albrecht & O'Brien, 1993; O'Brien & Albrecht, 1992). Over a number of studies O'Brien and colleagues have demonstrated that when a reader encounters information that is inconsistent with prior knowledge, reading times are disrupted (e.g. Cook, Halleran, & O'Brien, 1998; O'Brien, Cook, & Gueraud, 2010; O'Brien, Rizzella, Albrecht, & Halleran, 1998). However, Kendeou, Smith, & O'Brien (under review) have shown that as the amount of information that explains the potential contradiction is increased, the amount of disruption in reading is correspondingly decreased (see also: Gueraud, Harmon, & Peracchi, 2005). The same pattern was seen in the current results when the explanation served to facilitate comprehension of a correct outcome sentence by providing the reader with a detailed explanation of the correct belief.

Given the results from the present set of experiments, reading times demonstrate that refutation text can be highly sensitive to changes within existing memory structures. The current set of experiments was designed as a preliminary exploration in to the moment-by-moment processes involved in belief revision and offers a foundation for further work. The next step will be to begin to systematically explore the long-term impact of refutation texts on belief revision and assess the extent to which the degree of
belief revision maps on to the degree of facilitation measured in the reading times of correct outcome sentences.
References


Kendeou, P., Muis, K., & Fulton, S. (in press). Reader and text factors in reading
comprehension. *Journal of Research in Reading.*


APPENDIX A

The true/false inventory is presented in this appendix.
Please circle either True/False for the following statements

1. Pencils are filled with lead. T / F
2. The Korean War ended before World War II began T / F
3. Chameleons change color to match their surroundings T / F
4. Abraham Lincoln was assassinated at the White House T / F
5. The pilgrims first sailed to the U.S. on the Mayflower T / F
6. Van Gogh painted the Mona Lisa T / F
7. Lightning never strikes the same place twice T / F
8. Australia is the only country that is also a continent T / F
9. Modifiers of verbs are called adjectives T / F
10. Reading in dim light causes nearsightedness/myopia T / F
11. A heptagon has 8 sides T / F
12. Benjamin Franklin was the fifth president T / F
13. Meteors landing on Earth are hot T / F
14. Penguins live in the North Pole T / F
15. A spider is an insect T / F
16. Eating turkey makes people drowsy T / F
17. There are 31 days in the month of February T / F
18. Many of the planets were named after Roman gods T / F
19. 4 is the lowest prime number T / F
20. Ostriches bury their heads in the sand T / F
21. Red, blue, and green are all known as “primary colors” T / F
22. Egypt, Namibia, and Somalia are all countries in Africa T / F
23. The largest ocean is the Pacific T / F
24. Christopher Columbus was born in Spain T / F
25. People use approximately ten percent of their brains T / F
26. The capital of the United States is Washington D.C. T / F
27. The Indian ocean is the smallest in the world T / F
28. Seasons are caused by the distance between the Earth and the Sun T / F
29. The sun is mostly hydrogen T / F
30. Kilimanjaro is the tallest mountain in the world T / F
31. Napoleon Bonaparte was short T / F
32. Carrots, tomatoes, and corn are all vegetables T / F
33. Pluto was the Roman god of war T / F
34. Chimpanzee, orangutan, and howler are all types of monkeys T / F
35. If you drop two objects, the heavier one will fall faster T / F
36. The Gettysburg Address was a speech given by Thomas Jefferson T / F
37. Neil Armstrong was the first man to walk on the moon T / F
38. New Zealand is an island off the coast of Australia T / F
39. The radius of a circle is half of the circumference T / F
40. In baseball there are 6 outs in an inning T / F
APPENDIX B

The passages from Experiment I, II and III are presented in this appendix.
**Misconception:** Seasons are caused by the Earth being closer to the Sun in the summer than in the winter.

**Introduction**
The Parker family was vacationing at their favorite spot at a scenic New England lake. Every summer they would rent the same cabin right on the water. The two brothers, Danny and Ryan especially enjoyed the lake for water skiing and tubing. It was an exceptionally hot day so the boys decided to gear up for some water skiing. Danny had trouble adjusting his life jacket because his hands were dripping with sweat. Frustrated, he asked his brother why it was always so hot in the summer and always so cold in the winter. Mrs. Parker overheard her boys talking.

**Refutation Experiment I**
Ryan said that he thought it was because the Earth is closer to the Sun in the summer than in the winter. However, Mrs. Parker interrupted and said that this idea was incorrect. She explained to the boys that

**Non-Refutation Experiment I**
She said this was just the sort of thing that the boys should look up on the Internet later. Both of the sons agreed that they would look it up on the computer. When they did, they discovered that

**Refutation Experiment II**
Ryan said that he thought it was because the Earth is closer to the Sun in the summer than in the winter. However, Mrs. Parker interrupted and said that this idea was incorrect.

**Non-Refutation Experiment II**
She said this was just the sort of thing that the boys should look up on the Internet later. Both of the sons agreed that they would look it up on the computer.

**Explanation Experiment II**
She explained that the Earth is actually farther away from the Sun when it is summer in the Northern Hemisphere than when it is winter. Seasons are caused by the Earth being tilted on its axis. As the Earth orbits the Sun, different parts of the world receive different amounts of direct sunlight. Even though the Sun is farther away during summer, the Northern Hemisphere is tilted towards the Sun, causing longer days and more direct sunlight. In the winter, even though the Sun is closer, the Earth is tilted away from the Sun. So Mrs. Parker explained again that

**Non-Explanation Experiment II**
Mrs. Parker was always encouraging her boys to find out the answers to questions they had. She thought this was a good way to teach them because if they had to find the answers themselves, they would remember them better. Sometimes Danny and Ryan found this annoying. They would ask their mom what a certain word meant and rather than just tell them, they had to stop what they were doing and go find the dictionary.
They knew there was no point in asking her because their mom was not going to give them the answer. The first place they looked indicated that

**Explanation Experiment III**
She explained that the Earth is actually farther away from the Sun when it is summer in the Northern Hemisphere than when it is winter. Seasons are caused by the Earth being tilted on its axis. As the Earth orbits the Sun, different parts of the world receive different amounts of direct sunlight. Even though the Sun is farther away during summer, the Northern Hemisphere is tilted towards the Sun, causing longer days and more direct sunlight. In the winter, even though the Sun is closer, the Earth is tilted away from the Sun. So Mrs. Parker explained again that

**Non-Explanation Experiment III**
She was always encouraging her boys to find out the answers to any questions they had. She thought this was a good way to teach them because if they had to find the answers themselves, they would remember them better. Sometimes Jack and Ryan found this annoying. They would ask their mom what a certain word meant and rather than just tell them, they had to stop what they were doing and go find the dictionary. They knew there was no point in asking her because their mom was not going to give them the answer. The first place they looked indicated that

**Correct Outcome**
the tilt of the Earth causes the seasons.

**Spillover Sentence**
The boys were pleased with their answer.

**Closing**
They finished getting ready and climbed onto the back of the boat. They spent most of the afternoon water skiing until the sun went down and the temperature cooled off.

**Comprehension Question**
Were Danny and Ryan going water skiing?
Misconception: Meteors which land on earth are hot

Introduction
After a busy day at work, Kate was out for her nightly run. About halfway through the run, she stopped at a corner to rest and stretch. Kate looked up at the clear night sky while she took a sip from her water bottle. She saw a meteor falling beyond the trees and she watched until it hit the ground. She quickly ran about 400 yards to the site where the meteor landed. When she arrived there were already several people there. She noticed that her neighbor Jerry had also come down the street to see what was going on.

Refutation Experiment I
Kate warned everyone not to touch the meteor because it would be hot and they could get burned. However, Jerry said that they should not worry because it actually should not be hot. He explained to his neighbors that

Non-Refutation Experiment I
Kate was excited and curious because she had never seen a meteor on the ground before. Jerry said that he could look up more about meteors in the astrophysics book that he had. He read in his book that

Refutation Experiment II
Kate warned everyone not to touch the meteor because it would be hot and they could get burned. However, Jerry said that they should not worry because it actually should not be hot.

Non-Refutation Experiment II
Kate was excited and curious because she had never seen a meteor on the ground before. Jerry said that he could look up more about meteors in the astrophysics book that he had.

Explanation Experiment II
He explained that the high speed of the meteor when it enters the atmosphere causes it to melt or vaporize its outermost layer. The hot molten layer quickly blows off and the inside of the meteor does not have time to heat up again before passing through the atmosphere. This is because meteors are poor conductors of heat. Jerry told the crowd that many meteors that make it to Earth are actually found covered in frost. Despite this information, they all decided it was still a good idea not to touch it. Jerry spoke up again and assured them that

Non-Explanation Experiment II
He told them that he had always been very interested in space and had read many articles about the research that they have been conducting in the space program. Jerry was known for offering up facts and information to anyone that would listen to him. He was sure that his book with have all sorts of facts about meteors. He walked across the street to get the book from his house while more people gathered around the meteor. They could not believe a meteor landed in their very own town. When Jerry got back he told Kate that

Explanation Experiment III
He explained that the high speed of the meteor when it enters the atmosphere causes it to melt or vaporize its outermost layer. The hot molten layer quickly blows off and the inside of the meteor does not have time to heat up again before passing through the
atmosphere. This is because meteors are poor conductors of heat. Jerry told the crowd that many meteors that make it to Earth are actually found covered in frost. Despite this information, they all decided it was still a good idea not to touch it. Jerry spoke up again and assured them that

Non-Explanation Experiment III
He told them that he had always been very interested in space and had read many articles about the research that they have been conducting in the space program. Jerry was known for offering up facts and information to anyone that would listen to him. He was sure that his book with have all sorts of facts about meteors. He walked across the street to get the book from his house while more people gathered around the meteor. They could not believe a meteor landed in their very own town. When Jerry got back he told Kate that

Correct Outcome
meteors landing on Earth are always cold.

Spillover Sentence
Police cars were now starting to arrive.

Closing
The police told the crowd they had to go home because they needed to block off the area. Kate decided to sprint home to tell her family about the news.

Comprehension Question
Was Kate out for a walk?
Misconception: Napoleon Bonaparte was very short

Introduction
Professor Riley’s Art History class met in a large lecture hall this semester. Whenever he could Professor Riley showed the class portraits of historical figures so he could discuss what was going on at the time of the painting. The students liked the class because their instructor was very animated. Today’s class was going to be about French paintings and Professor Riley was ready to begin. A slide came up with a serious looking man. Professor Riley asked his favorite student Emily who the man was. When she had no guess, he informed the class that it was Napoleon Bonaparte.

Refutation Experiment I
Emily said she did not think this could be Napoleon because the man in the painting was tall and she believed Napoleon was short. Professor Riley said that this was actually not true. He explained to the class that

Non-Refutation Experiment I
Emily was delighted to hear this answer because she loved French history and culture. She was actually getting her minor in French and planned to go abroad to Paris during the next semester. Professor Riley explained to them that

Refutation Experiment II
Emily said she did not think this could be Napoleon because the man in the painting was tall and she believed Napoleon was short. Professor Riley said that this was actually not true.

Non-Refutation Experiment II
Emily was delighted to hear this answer because she loved French history and culture. She was actually getting her minor in French and planned to go abroad to Paris during the next semester.

Explanation Experiment II
He explained that in 1821, not long after his death, Napoleon Bonaparte was measured at 5 feet 2 inches in French feet. This same measurement would be the equal to 5 feet 6.5 inches in modern day international feet, or 1.69 meters. This was slightly taller than the average Frenchman during the 19th century. People often thought he was short because there was great confusion between the systems of measurement. They confused the old measurement system of French feet and the feet used today. Professor Riley said that many people still think of Bonaparte as having been short when actually

Non-Explanation Experiment II
Emily often talked with Professor Riley about French artists after class. He told her about the painters that worked along the river near the Eiffel Tower. He also told her about the many famous art museums like the Louvre. Emily knew that Paris was a wonderful place to study both art and history because Professor Riley included many French artists in his lessons. Although she had learned quite a bit about France, this was the first time Emily had ever seen a painting of the French dictator. Professor Riley pointed out the man’s regal appearance and told the class that

Explanation Experiment III
He explained that in 1821, not long after his death, Napoleon Bonaparte was measured at 5 feet 2 inches in French feet. This same measurement would be the equal to 5 feet 6.5 inches in modern day international feet, or 1.69 meters. This was slightly taller than the average Frenchman during the 19th century. People often thought he was short because there was great confusion between the systems of measurement. They confused the old measurement system of French feet and the feet used today. Professor Riley said that many people still think of Bonaparte as having been short when actually

**Non-Explanation Experiment III**
Emily often talked with Professor Riley about French artists after class. He told her about the painters that worked along the river near the Eiffel Tower. He also told her about the many famous art museums like the Louvre. Emily knew that Paris was a wonderful place to study both art and history because Professor Riley included many French artists in his lessons. Although she had learned quite a bit about France, this was the first time Emily had ever seen a painting of the French dictator. Professor Riley pointed out the man’s regal appearance and told the class that

**Correct Outcome**
Napoleon was average height for his time.

**Spillover Sentence**
There were several portraits of the ruler.

**Closing**
The portrait made Emily want to learn more about Napoleon and other French leaders. She decided that she would go to the library after class to take out some books.

**Comprehension Question**
Was Emily’s class at the art museum?
**Misconception:** Chameleons change color to match their surroundings.

**Introduction**
Jack was in his bedroom playing with his favorite green lizard stuffed animal. He did everything with his lizard by his side. Today Jack had gotten an idea while reading one of his lizard books. He went to his pencil box and got out a bright blue permanent marker, exactly the shade of his bedspread. He took it back to his bed and began coloring his lizard. Midway through coloring, his older brother Ben walked in and asked what he was doing. Jack explained that his lizard was a chameleon and that he was changing colors to match his background.

**Refutation Experiment I**
Jack said that he saw the chameleon in his book change colors and that he believes that chameleons change color to match their surroundings. His brother told him that this was not true. Ben explained that he learned that

**Non-Refutation Experiment I**
Ben said that he was going to get in trouble for coloring his toy. This was the second time this week Mom would yell at him for coloring on something other than paper. Ben explained that he learned that

**Refutation Experiment II**
Jack said that he saw the chameleon in his book change colors and that he believes that chameleons change color to match their surroundings. His brother told him that this was not true.

**Non-Refutation Experiment II**
Ben said that he was going to get in trouble for coloring his toy. This was the second time this week Mom would yell at him for coloring on something other than paper.

**Explanation Experiment II**
Ben shook his head and told Jack he was in trouble and more importantly he was not even right about chameleons. Ben explained what he learned in biology class. He said that a chameleon’s change in color is an expression of the physical and physiological condition of the lizard. Chameleons are already naturally camouflaged to match their surroundings, and change their colors depending on their mood, and sometimes as a signal of communication. Ben said that a chameleon turns black when it is scared. He told Jack that he should not have colored the lizard to match his background because

**Non-Explanation Experiment II**
Jack was always getting into trouble for being mischievous. He often had big plans that usually included his lizard and a big mess to clean. Almost every day Jack would climb up to his tree house in the backyard and bring his lizard along to spy on the neighbors, and sometimes on his family. His favorite game to play with his lizard was bug hunt where he would crawl around to catch all kinds of insects in a jar. Ben thought his brother was weird. He looked at Jack with the marker and rolled his eyes because he knew that

**Explanation Experiment III**
Ben shook his head and told Jack he was in trouble and more importantly he was not even right about chameleons. Ben explained what he learned in biology class. He said that a chameleon’s change in color is an expression of the physical and physiological condition of the lizard. Chameleons are already naturally camouflaged to match their surroundings, and change their colors depending on their mood, and sometimes as a signal of communication. Ben said that a chameleon turns black when it is scared. He told Jack that he should not have colored the lizard to match his background because

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Correct Outcome
chameleons change color to reflect a mood.

Spillover Sentence
Jack looked at his chameleon with concern.

Closing
He hoped he would be able to get the marker off of his lizard. Maybe his mom would put it in the wash for him if he asked her nicely.

Comprehension Question
Was Jack coloring his lizard blue?
**Misconception:** People only use 10% of their brains.

**Introduction**
Kim really enjoyed her psychology class this semester. As part of the class she had the opportunity to take part in a real research study. She decided to sign up for a study that used brain imaging technology. The goal of the study was to see what areas of the brain were active when performing specific experimental tasks. Kim could not wait to see the pictures of her own brain. After the study was finished, the researcher showed her the images. She noticed that during some parts of the task, a large proportion of her brain seemed to light up.

**Refutation Experiment I**
Kim told the researcher she did not think the pictures could be right because she believed people only use ten percent of their brain. The researcher explained that this is not the case. He told Kim that people actually

**Non-Refutation Experiment I**
The researcher told her that she might be interested in taking a course in cognitive neuroscience. He explained that this was just the kind of thing they would learn about in that class. He told Kim that people actually

**Refutation Experiment II**
Kim told the researcher she did not think the pictures could be right because she believed people only use ten percent of their brain. The researcher explained that this is not the case.

**Non-Refutation Experiment II**
The researcher told her that she might be interested in taking a course in cognitive neuroscience. He explained that this was just the kind of thing they would learn about in that class.

**Explanation Experiment II**
He explained that many people hold this belief but it is actually incorrect. Recent brain imaging studies have shown that activation occurs in well over ten percent of the human brain. Different areas of the brain show activation during several different tasks. The researcher then explained that this myth had first started at least as far back as the early twentieth century. It may have started with the famous psychologist William James who used the statement only metaphorically. More recently, people have misinterpreted studies within the field of neuroscience as being support for the myth. But research shows that humans

**Non-Explanation Experiment II**
Kim wanted to know more about brain imaging technology and how much of the brain we use. She asked the researcher if there were any opportunities for her to get experience in his lab. He told her that if she was interested, she could work in the lab as a research assistant in her free time during the school year. If she liked it, she could continue working there during the summer. Kim said that she would love the opportunity to be a research assistant. The researcher told her she would learn many things about the brain including that humans

**Explanation Experiment III**
The researcher explained that many people hold this belief but it is incorrect. Recent brain imaging studies have shown that activation occurs in well over ten percent of the human brain. Different areas of the brain show activation during several different tasks. The researcher then explained that this myth had first started at least as far back as the early twentieth century. It may have started with the famous psychologist William James who used the statement only metaphorically. More recently, people have misinterpreted studies within the field of neuroscience as being support for the myth. But research shows that humans

**Non-Explanation Experiment III**
Kim wanted to know more about brain imaging technology and how much of the brain we use. She asked the researcher if there were any opportunities for her to get experience in his lab. He told her that if she was interested, she could work in the lab as a research assistant in her free time during the school year. If she liked it, she could continue working there during the summer. Kim said that she would love the opportunity to be a research assistant. The researcher told her she would learn many things about the brain including that humans

**Correct Outcome**
use well over ten percent of their brain.

**Spillover Sentence**
He said human brains are really complex.

**Closing**
The new technology that we now have allows researchers to further explore how the brain works. New studies in neuroscience continue to reveal things that we did not previously know.

**Comprehension Question**
Was Kim taking part in a research study?
**Misconception:** Two balls, same size, heavier ball will hit the ground first

**Introduction**
Tom loved all of his classes this year but science was still his favorite subject. His teacher Mrs. James enjoyed having Tom in class because he was very enthusiastic. She encouraged him to conduct his own simple experiments. After school one day Tom was testing something he learned that day. He had two balls that were exactly the same size and shape but one weighed twice as much as the other. He planned to drop both balls from the roof of his house at the same time. He wanted to see which one of the two balls would fall faster.

**Refutation Experiment I**
Tom had initially believed that if two objects were the exact same shape and size but one was heavier, the heavier object would fall faster. His teacher explained that this idea was incorrect. The experiment would show Tom that

**Non-Refutation Experiment I**
Tom wanted to know whether the difference in weight would have any impact on the rate that the balls would each fall. His teacher said that this experiment would be easy to conduct. The experiment would show Tom that

**Refutation Experiment II**
Tom had initially believed that if two objects were the exact same shape and size but one was heavier, the heavier object would fall faster. His teacher explained that this idea was incorrect.

**Non-Refutation Experiment II**
Tom wanted to know whether the difference in weight would have any impact on the rate that the balls would each fall. His teacher said that this experiment would be easy to conduct.

**Explanation Experiment II**
She explained to Tom that when you drop two identically shaped objects that have different masses, the two objects will experience the exact same acceleration due to gravity. This is because gravity acts on all objects in exactly the same manner and this occurs regardless of their mass. It does not make a difference if one of the objects weighs more than the other object. That is to say, gravity will exert the same pull on both of them. Therefore the balls will fall at exactly the same rate. Tom's experiment was going to show that

**Non-Explanation Experiment II**
She explained that it would be interesting to know whether two identically shaped objects of different masses, would experience the exact same acceleration due to gravity. She told him that doing these kinds of experiments would help him to gain a better understanding of what he learned in class. She often encouraged her students to conduct simple tests outside of class. Not only was it helpful for tests and assignments, but it was also very good practice if he was interested in becoming a scientist. He planned to conduct the experiment after school. The experiment was going to show that

**Explanation Experiment III**

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Tom learned at school that when you drop two identically shaped objects that have different masses, the two objects will experience the exact same acceleration due to gravity. This is because gravity acts on all objects in exactly the same manner and this occurs regardless of their mass. It does not make a difference if one of the objects weighs more than the other object. That is to say, gravity will exert the same pull on both of them. Therefore the balls will fall at exactly the same rate. Tom’s experiment was going to show that

**Non-Explanation Experiment III**
Mrs. James said it would be interesting to know whether two identically shaped objects of different masses, would experience the exact same acceleration due to gravity. She told him that doing these kinds of experiments would help him to gain a better understanding of what he learned in class. She often encouraged her students to conduct simple tests outside of class. Not only was it helpful for tests and assignments, but it was also very good practice if he was interested in becoming a scientist. He planned to conduct the experiment after school. The experiment was going to show that

**Correct Outcome**
the balls hit the ground at the same time.

**Spillover Sentence**
Tom was ready to conduct the experiment.

**Closing**
He was excited to tell his teacher about it the next day in school. He hoped she would be impressed and suggest other experiments that he could do at home.

**Comprehension Question**
Was science Tom’s favorite subject?
Misconception: Reading in dim light ruins your eyes/causes nearsightedness (myopia)

Introduction
During a big snowstorm Kristen was stuck inside reading three chapters for her American Government class. This was her least favorite class because the reading was so boring. Her parents insisted that she spend the day studying because she was falling behind in class. They told her that she needed to bring up her grade. If she did not, she would have to quit the school basketball team. Just as she started reading about how a bill becomes a law, the power in the house went out. It was not completely dark but Kristen felt it was too dim to read.

Refutation Experiment I
Kristen told her mother that she could not read because she would strain her eyes in the dim light and become nearsighted. Her mother, an eye doctor, explained that this was not true. She said Kristen should not worry because

Non-Refutation Experiment I
Kristen told her mother that she could not read because there was not enough light. Her mother said that it was really important for her to catch up and she should try harder. She said Kristen should not worry because

Refutation Experiment II
Kristen told her mother that she could not read because she would strain her eyes in the dim light and become nearsighted. Her mother, an eye doctor, explained that this was not true.

Non-Refutation Experiment II
Kristen told her mother that she could not read because there was not enough light. Her mother said that it was really important for her to catch up and she should try harder.

Explanation Experiment I
She told Kristen that although it is possible to strain your eyes by reading in dim light, the symptoms are not permanent. Reading in dim light would not cause myopia. She explained that there is a current theory suggesting that nearsightedness, or myopia, might be caused by reading in dim light or holding books too close to the face. However, there are several studies that have demonstrated that reading in dim light does not permanently damage your eyes. She told Kristen that she could use a flashlight. She said that this might be easier but she should not worry because

Non-Explanation Experiment II
She explained that even if she thought the subject was boring, she needed to learn how her country’s government worked. The class also meant a lot to Kristen’s dad because he was a state representative and wanted his daughter to get involved in politics. He thought his daughter would make a great politician. Her mother explained that it was also important for her to get a good grade because she would be applying to colleges soon. American Government was an advanced course that would look good on her transcript. She told Kristen that she needed to keep reading and that

Explanation Experiment III
Kristen's mom said that although it is possible to strain your eyes by reading in dim light, the symptoms are not permanent. Reading in dim light would not cause myopia. She explained that there is a current theory suggesting that nearsightedness, or myopia, might be caused by reading in dim light or holding books too close to the face. However, there are several studies that have demonstrated that reading in dim light does not permanently damage your eyes. She told Kristen that she could use a flashlight. She said that this might be easier but she should not worry because

**Non-Explanation Experiment III**
Kristen’s mom explained that even if she thought the subject was boring, she needed to learn about her country’s government. The class also meant a lot to Kristen’s dad because he was a state representative and wanted his daughter to get involved in politics. He thought his daughter would make a great politician. Her mother explained that it was also important for her to get a good grade because she would be applying to colleges soon. American Government was an advanced course that would look good on her transcript. She told Kristen that she needed to keep reading and that

**Correct Outcome**
reading in dim light cannot hurt her eyes.

**Spillover Sentence**
Kristen went to find the big flashlight.

**Closing**
She was afraid if she read without one she might fall asleep on the book. She got a glass of water before sitting back down at her desk to study.

**Comprehension Question**
Was Kristen studying for her history test?
Misconception: Eating turkey makes people especially drowsy

Introduction
It was Thanksgiving Day and the entire Clark family was together to celebrate. Uncle Charlie promised the kids that he would take them outside to play after dinner. The meal was especially delicious and very filling. Uncle Charlie ate two large helpings of turkey along with stuffing, potatoes with gravy, and cranberry sauce. He then helped himself to two pieces of pie. After he finished, he sat on the couch and began to fall asleep in front of the football game. The kids started jumping on him and told him to wake up and take them outside like he promised.

Refutation Experiment I
Charlie said he could not help falling asleep because turkey contains a natural drug that makes people sleepy. His wife called from the kitchen and told the kids that Uncle Charlie was wrong. She explained to the kids that

Non-Refutation Experiment I
Charlie said he could not help falling asleep because he was really tired. His wife called from the kitchen and said that he should not break his promise and take the kids out. She explained to her husband that

Refutation Experiment II
Charlie said he could not help falling asleep because turkey contains a natural drug that makes people sleepy. His wife called from the kitchen and told the kids that Uncle Charlie was wrong.

Non-Refutation Experiment II
Charlie said he could not help falling asleep because he was really tired. His wife called from the kitchen and said that he should not break his promise and take the kids out.

Explanation Experiment II
She explained that there is an amino acid in turkey called tryptophan which is known to cause drowsiness. However there is just as much tryptophan in pork and cheese. She also said that tryptophan only promotes sleep if you ingest it on an empty stomach, with no protein present. Since turkey includes protein, his sleepiness could not have been from the turkey. His wife said it was more likely that his drowsiness was caused by a decrease in blood flow and oxygenation to the brain because he overate. She encouraged the kids to keep asking him to go outside because

Non-Explanation Experiment II
She said that Uncle Charlie knew how important it was to keep promises. Besides, it would be good for him to get some fresh air and spend some time with his nieces and nephews. Uncle Charlie was their favorite uncle and they loved to play games with him. On top of that, exercise was just what he needed after eating such a big meal. She decided to join the kids outside to work off some of the extra calories. After helping the kids get on their shoes and coats, she coaxed her husband off of the couch telling him that

Explanation Experiment III
Uncle Charlie’s wife explained that there is an amino acid in turkey called tryptophan which can cause drowsiness. However there is just as much tryptophan in pork and cheese. She also said that tryptophan only promotes sleep if you ingest it on an empty
stomach, with no protein present. Since turkey includes protein, his sleepiness could not have been from the turkey. His wife said it was more likely that his drowsiness was caused by a decrease in blood flow and oxygenation to the brain because he overate. She encouraged the kids to keep asking him to go outside because

**Non-Explanation Experiment III**
Their aunt said that Uncle Charlie knew that keeping promises was very important. Besides, it would be good for him to get some fresh air and spend some time with his nieces and nephews. Uncle Charlie was their favorite uncle and they loved to play games with him. On top of that, exercise was just what he needed after eating such a big meal. She decided to join the kids outside to work off some of the extra calories. After helping the kids get on their shoes and coats, she coaxed her husband off of the couch telling him that

**Correct Outcome**
turkey does not make people feel sleepy.

**Spillover Sentence**
Uncle Charlie stood up and went outside.

**Closing**
He enjoyed running around with the kids in the yard. He also decided that if he got some exercise now he could have another piece of pie later that night.

**Comprehension Question**
Did Charlie skip dessert?
Misconception: Ostriches bury their heads in the sand.

Introduction
Julie and Brian were adventurous newlyweds that decided to take an African safari for their honeymoon. The couple was known for being risk-takers and they loved to try new things. They had both been planning for this trip for several months. Their first day on the savannah was a day-long trek where their guide promised they would see lots of wild animals. The guide had not exaggerated; they saw zebras, elephants, monkeys and lions. Julie was thrilled when she looked up and saw a large ostrich in the distance. She could only see the ostrich’s body and not his head.

Refutation Experiment I
Julie thought the ostrich had buried his head in the sand and pointed that out. The guide told them that ostriches actually do not bury their heads in the sand like Julie thought. Although many people think otherwise, ostriches

Non-Refutation Experiment I
Julie asked the guide if it was safe to take a closer look to snap some better photos. The guide said that it was safe and he drove closer to the large bird. He told the couple that ostriches

Refutation Experiment II
Julie thought the ostrich had buried his head in the sand and pointed that out. The guide told them that ostriches actually do not bury their heads in the sand like Julie thought.

Non-Refutation Experiment II
Julie asked the guide if it was safe to take a closer look to snap some better photos. The guide said that it was safe and he drove closer to the large bird.

Explanation Experiment II
He explained that people often think that ostriches bury their heads in the sand but this was because the male ostrich digs a large hole in the sand for their eggs. They do this to protect the eggs from predators. The female and male then take turns sitting on the eggs. They turn their eggs with their beak several times a day during the incubation period. From a distance it often looks like the bird has buried its head in the sand because when they reach into the hole their heads blend into the horizon. The guide clarified that ostriches

Non-Explanation Experiment II
When he stopped the car Julie started to snap some photos with her camera. She asked Brian if he could record the ostrich on film so they could show all of their friends and family. Neither of them had ever seen a real one outside of a book. They had both heard that the birds were very fast and asked the guide if this was true. He told them that ostriches can run up to forty-five miles per hour which made them the fastest bird on land. He also said that ostriches are interesting because contrary to popular belief, they

Explanation Experiment III
Their guide explained that people often think that ostriches bury their heads in sand but this was because the male ostrich digs a large hole in the sand for their eggs. They do this to protect the eggs from predators. The female and male then take turns sitting on the
eggs. They turn their eggs with their beak several times a day during the incubation period. From a distance it often looks like the bird has buried its head in the sand because when they reach into the hole their heads blend into the horizon. The guide clarified that ostriches

**Non-Explanation Experiment III**

Their guide stopped the car and Julie started to snap photos with her camera. She asked Brian if he could record the ostrich on film so they could show all of their friends and family. Neither of them had ever seen a real one outside of a book. They had both heard that the birds were very fast and asked the guide if this was true. He told them that ostriches can run up to forty-five miles per hour which made them the fastest bird on land. He also said that ostriches are interesting because contrary to popular belief, they do not ever bury their heads in the sand.

**Correct Outcome**
do not ever bury their heads in the sand.

**Spillover Sentence**
Julie looked through some of her photos.

**Closing**
They headed back to their camp when the sun started to go down. They were both exhausted when they got back so they ate dinner and went right to bed.

**Comprehension Question**
Was the couple on their honeymoon?
Misconception: Lightning never strikes the same place twice.

Introduction
Matthew was picked to host the annual sleep over for his little league team. Everyone knew Matthew’s house because it was the white Victorian with the giant oak tree in the front yard. The tree had been struck by lightning years before and you could still see the damage on the trunk. The night of the sleep over a heavy storm rolled in. The boys arrived with their sleeping gear and huddled in the front window. They were hoping they might get to see the giant oak get hit by lightning again. Matthew’s dad joined the boys by the window.

Refutation Experiment I
He told the boys that they should watch somewhere other than the tree because lightning never strikes the same place twice. However the boys learned in school that this is not the case. Their teacher had told them that

Non-Refutation Experiment I
He told the boys that he remembered the night when the big oak tree had been struck. Everyone in town said that it was one of the worst storms they had ever had. Matthew said he had learned that

Refutation Experiment II
He told the boys that they should watch somewhere other than the tree because lightning never strikes the same place twice. However the boys learned in school that this is not the case.

Non-Refutation Experiment II
He told the boys that he remembered the night when the big oak tree had been struck. Everyone in town said that it was one of the worst storms they had ever had.

Explanation Experiment II
Their teacher Miss Benson taught their class that there is not a single reason why lightning would not be able to strike the same place more than once. There is nothing that prevents this from happening. In fact, she told them that some of the world’s tallest buildings are struck many times a year. The tallest points in an area are more likely to be struck by lightning even if they have already been struck before. The boys decided to keep watching the oak tree because it was the tallest point in the entire neighborhood. After all, they knew that

Non-Explanation Experiment II
He told them that when they first moved into the house he thought about putting up a tree house in the oak tree. Matthew’s mom thought it would be dangerous so they agreed on a tire swing instead. The night of the first big storm he and Matthew’s mom had put Matthew to bed and sat down to watch a movie. They saw the flash of lightning and heard a very loud crack when the tree got hit. It was strong enough to make a split right down the thick tree trunk. The boys hoped this would happen again because

Explanation Experiment III
Their teacher Miss Benson had taught their class that there is not one reason why lightning would not be able to strike the same place more than once. There is nothing that prevents this from happening. In fact, she told them that some of the world’s tallest
buildings are struck many times a year. The tallest points in an area are more likely to be struck by lightning even if they have already been struck before. The boys decided to keep watching the oak tree because it was the tallest point in the entire neighborhood. After all, they knew that

**Non-Explanation Experiment III**

He told them that when they first moved into the house he thought about putting up a tree house in the oak tree. Matthew's mom thought it would be dangerous so they agreed on a tire swing instead. The night of the first big storm he and Matthew's mom had put Matthew to bed and sat down to watch a movie. They saw the flash of lightning and heard a very loud crack when the tree got hit. It was strong enough to make a split right down the thick tree trunk. The boys hoped this would happen again because

**Correct Outcome**

lightning can strike the same place twice.

**Spillover Sentence**

They continued staring out the big window.

**Closing**

After eating dinner, they set their sleeping bags up in the front room. They stayed up late telling ghost stories and watching the storm until they fell asleep at midnight.

**Comprehension Question**

Was Matthew's soccer team having a sleepover?
APPENDIX C

For all experiments reported in this thesis, approval for human subjects was obtained from the University of New Hampshire Psychology Department Internal Review Board. Forms demonstrating proof of approval are included in this Appendix.
Name: ERINN K. WALKH
Dept: PSYCHOLOGY
Study: MISCONCEPTIONS

Departmental Review Committee Exemption Classification Sheet

The proposed research meets one or more of the following categories:

- Published or commonly accepted educational, testing, or evaluation procedures or observation of public behavior unless:
  - the information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects, and
  - the research could result in the subjects' financial condition or in criminal or civil liability or be damaging to subjects;

- Procedures involving the use of educational tests (cognitive, diagnostic, aptitude, achievement) of procedures or observation of public behavior that is not exempt;

- Human subjects are elected or appointed public officials or candidates for public office;

- Collection or study of existing data, documents, records,

- Research and demonstration projects which are conducted by or subject to the approval of an agency or organization, and which are designed to study, evaluate, or otherwise examine: (i) Public or private education, training, or other programs; (ii) Procedures for obtaining benefits or services under those programs; (iii) Alternatives to those programs or procedures; or (iv) Possible changes in methods of service delivery or payment for benefits or services under those programs;

- Food and food quality evaluation and consumer acceptance studies, (i) if wholesome food or water supplies are consumed, or (ii) if a food is consumed that contains a food ingredient or additive known and not found to be safe, or agricultural chemical or environmental contaminants found to be safe, by the Food and Drug Administration, or approved by the Environmental Protection Agency, or the Food Safety and Inspection Service of the U.S. Department of Agriculture;

- Research is approved as presented in the category checked:

- Research is approved with the following contingencies/comments (attach sheets if necessary):

- Research is referred to the IRB for Expedited or Full Board review:

- Research cannot be approved as presented (cite reasons on separate sheet):

DRC Reviewer: 
Date: 7/28/11