The Effects of Arousal Presented by a Pedagogical Agent on English Language Learners' Situational Interest, Cognitive Load and Reading Comprehension in Online Reading Tasks

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The Effects of Arousal Presented by a Pedagogical Agent on English Language Learners' Situational Interest, Cognitive Load and Reading Comprehension in Online Reading Tasks

by

Jack Drobisz

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Curriculum and Instruction with an emphasis in Instructional Technology Department of Educational and Psychological Studies College of Education University of South Florida

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Keywords: instructional technology, pedagogical agent, situational interest

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ABSTRACT

This research examined how four different animated pedagogical agent implementations, which focus on perceptual and inquiry arousal conditions of attention as defined in Keller’s ARCS model of motivational design (Keller, 2009), impact English language learners' situational interest, cognitive load, and reading comprehension in online readings tasks. Animated pedagogical agents (APA) are computer characters embodied with speech, gestures, or movement (Sweller, Ayres, & Kalyuga, 2011), which according to cognitive-affective theory of learning with media (CATLM; Moreno, 2005; Moreno & Mayer, 2007), can provide a mechanism for triggering situational interest in reading materials through different arousal conditions. In this study, perceptual arousal and inquiry arousal were implemented in two different levels within four APA conditions: high perceptual arousal and high inquiry arousal condition, high perceptual and low inquiry condition, low perceptual and high inquiry condition, and low perceptual and low inquiry condition. Study outcome variables included situational interest, cognitive load, and reading comprehension. Situational interest is a psychological construct defined as a specific person-to-topic relationship, which is triggered by the instructional environment during the first stage of a 4-phase model of interest development (Hidi & Renninger, 2006; Krapp, 2002). In this study, situational interest was operationally defined as a self-reported degree of attention and an affective reaction to environmental stimuli; situational interest was measured using a 6-item, 5-point Likert-scale instrument adopted from Rotgans and Schmidt’s (2011b) experiment. Cognitive load is defined in cognitive load theory as a mental effort in working memory, part of which may contribute to formation of mental schemas in long-
term memory structures (Sweller et al., 1998, p. 259). In this study, three types of cognitive load were examined, including extraneous cognitive load, intrinsic cognitive load, and germane cognitive load. The three types of cognitive load were operationally defined as self-reported complexity, clarity and effectiveness of the presentation, and increase in knowledge and understanding of a topic. The three types of cognitive load were measured using a 10-item, 11-point Likert-scale questionnaire, which was validated in prior studies (Leppink et al., 2013). The last outcome variable, reading comprehension, was measured using multiple-choice recall and understanding questions included with each original text passage. This study did not find any evidence of perceptual or inquiry arousal effects on situational interest, however, disordinal interaction between perceptual and inquiry arousal levels on germane cognitive load was found. Also, a main effect of inquiry arousal levels on reading comprehension was discovered.
CHAPTER ONE: INTRODUCTION

In general, interest has long been considered a key factor in motivation and learning (Dewey, 1913). Interest in content restricted to a specific context, referred to as “situational interest,” had been linked to attention in numerous studies (e.g., Ainley, Hidi, & Berndorff, 2002; Heidi, Renninger, & Krapp, 2004; McDaniel, Waddill, Finstad, & Bourg, 2000). Situational interest that is caused by a specific event (i.e., triggered situational interest) is a critical first phase of a 4-phase model of interest development (Krapp, 2002; Hidi & Renninger, 2006). Based on Keller’s attention, relevance, confidence, satisfaction (ARCS) model of motivation, arousing attention is the first essential step in triggering interest and motivation in instructional environments (Keller, 2009). According to Keller, without perceptual or inquiry arousal triggers, it may be impossible to capture students’ attention, and any potential learning benefits from situational interest and motivation will not be realized. This may be especially true in reading tasks that involve large blocks of text.

Recreational reading in the Western world is on decline (Organization for Economic Cooperation and Development [OECD], 2010; Mol & Bus, 2011), and many educators are concerned about this trend since recreational reading is considered to be one of the key factors in developing reading comprehension skills (Cox & Guthire, 2001; Share, 2008). Although many students in the U.S. are proficient readers, they often struggle with reading comprehension, which is known to impact individuals’ academic and professional success (Gottfried, Schlackman, Gottfried, & Boutin-Martinez, 2015; Mol & Bus, 2011; Notten, 2011; OECD,
2010; Taylor, 2013). This lack of interest in recreational reading and weaker reading comprehension skills may be compounded by the cultural diversity of American English language learners who are less likely to share similar topics of interests as their American-born peers. English language learners are not only faced with additional language learning challenges, but they are often confronted with reading materials targeting generalized school populations which they may find less interesting or engaging – based on Hofstede's idea of cultural dimensions (Hofstede et al., 1991; Tapanes et al., 2009). The subject population selection for this experimental study was partially driven by convenience, but also by the assumption that finding interesting topics, and reading itself, is more challenging to English language learners, resulting in higher cognitive loads in online reading tasks, and leading to decreased reading comprehension. Some of these challenges are also likely to be present among native English speaking struggling readers, which should provide additional support for the external validity of this study.

Traditional recreational reading activity among American youth is in direct competition with multimedia, computer, and network technologies which enable mobile devices, social networks, and computer games, all of which present seductive alternatives to reading. It has been suggested that the vacuous short statements, pictures, and interactions available through these new media are highly addictive and time consuming, yet provide minimal educational benefit (Turkle, 2015). Naturally, educational researchers have been asking themselves how these new technologies can be properly harnessed to make recreational reading and textual materials themselves immediately more attractive and interesting. One possible solution is to insert short, intrinsically motivating games between electronic text pages, which require certain levels of reading comprehension to advance to the next page (Smith et al., 2013). Another
promising approach uses multimedia texts with embedded pedagogical agents and speech to increase student motivation, situational interest, and learning outcomes (Park, 2015). This research study builds upon a previous work with pedagogical agents embedded in multimedia text but focuses specifically on the yet unexplored question of how the two arousal conditions described by Keller affect situational interest, cognitive loads, and reading comprehension of textual materials with integrated pedagogical agents.

Pedagogical agents are virtual characters embodied with human-like qualities of speech, gestures, or movement (Sweller, Ayres & Kalyuga, 2011) that are known to improve learning in multimedia environments (Schroeder & Adesope, 2014). With recent advances in computing hardware and network technologies, animated pedagogical agents are becoming more accessible and common (Gholson & Craig, 2002; Johnson, Rickel, & Lester, 2000), but their role in the development of situational interest that supports reading tasks has not yet been investigated.

Prior research suggests that interactions with pedagogical agents built upon multimedia design principles can improve motivation and learning outcomes (Heidig et al, 2014; Mayer & Estrella, 2014; Plass et al., 2012; Um et al., 2011). These principles are based on the prior research and theoretical foundations of Cognitive Theory of Multimedia Learning (CTML; Mayer, 2009). The cognitive-affective theory of learning with media (CATLM; Moreno, 2005; Moreno & Mayer, 2007) extends the CTML to media such as virtual reality or agent-based learning environments that present learners with interactive instructional materials, rather than just words and pictures. CTML and CATLM are supported by cognitive load theory (CLT; Plass, Moreno & Brünken, 2010) and the dual channel assumption of dual coding theory proposed by Paivio (1971). Together, these theoretical models provide foundations for affective
designs of multimedia materials, and support the use of animated pedagogical agents with attention arousal triggers in multimedia texts.

There are a number of multimedia design principles, derived from CLT, CTML, and CATML theoretical models, which can guide the development of effective pedagogical agents, but few motivational theories to inform the design of agents intended to trigger situational interests. One of them, the ARCS model of motivational design developed by John Keller, is a well-known conceptual framework for guiding development of instructional materials. It consists of four components: attention, relevance, confidence and satisfaction (Keller, 1987). The first component, attention, is subdivided into three types of sub-components: (a) perceptual arousal, (b) inquiry arousal, and (c) variability. This study particularly examines the first two types of stimuli, perceptual arousal and inquiry arousal, and how they apply to pedagogical agents. Due to the novelty, short duration, and non-repetitive nature of the multimedia texts with embedded pedagogical agents, variability is not considered to be a significant factor contributing to attention in this research study. Perceptual arousal (PERA) and inquiry arousal (INQA) pedagogical agent designs were guided by the instructional design principles of CATLM and CTML theoretical models, all of which are described in Chapter 2.

Situational interest is known to promote reading engagement (Flowerday et al., 2010). Multimedia texts with pedagogical agents have been shown to improve interest and learning from texts (Park, 2015). Interesting texts require fewer cognitive resources (McDaniel et al., 2000) and designs that affect emotions can stimulate interest and improve learning through increased generative processing (Heidig et al., 2014; Mayer & Estrella, 2014; Plass et al., 2012; Um et al., 2011;). However, research literature to guide the “situationally interesting” designs of pedagogical agents embedded in “boring” informational texts is currently lacking. This study
focuses on a gap in knowledge existing at the intersection of arousal conditions and situational interest development in multimedia texts as it examines the impact of perceptual and inquiry arousal conditions embedded in pedagogical agents on situational interest, cognitive load, and reading comprehension of textual reading materials.

**Problem Statement**

One of the largest problems facing instructional designers is how to trigger and maintain students’ attention without distracting them from the learning content (Harp & Mayer, 1998). Well-designed pedagogical agents, based on multimedia design principles, are known to promote attention through situational interest and increase generative processing in multimedia learning without increasing extraneous cognitive load (Park, 2015). However, it is not clear how two different types of arousal conditions described by Keller (2009)—perceptual arousal and inquiry arousal—affect students' situational interest, perceived germane cognitive load, and achievement when integrated into animated pedagogical agents.

**Purpose of the Study**

This study examines the effects of perceptual and inquiry arousal events, integrated into animated pedagogical agents, on situational interest, cognitive load, and comprehension in online reading tasks. This research inquiry also provides new insight into the design of agent-based reading tasks incorporating two different types of attention arousal.

**Research Design**

To test the hypotheses presented in Chapter 2, this study employed a randomized controlled, posttest-only 2x2 between subjects factorial design. The reason for this design is to measure any main effects of the two independent variables and any interaction effects between
them. This type of design is widely used and accepted in educational research (Campbell & Stanley, 2015) for the purpose of evaluating different instructional treatments or instruments. The independent variables of this study are the two types of perceived arousal: perceptual arousal (PERA) and inquiry arousal (INQA). This study manipulated each arousal type in two levels, high and low, by varying the degree of each arousal presented by a pedagogical agent in online English reading tasks. The two independent variables yield four combinations of high-PERA, high-INQA, low-PERA, and low-INQA conditions.

This study targets a population of English language learners, who are loosely defined as people in need of development of effective English language reading and comprehension skills. One hundred and fifty-nine international students were recruited to participate in this study from an English language program at a large Southeastern US university and randomly assigned to one of the four groups of approximately 40 students each.

Random assignment was performed among all 18 class sections of students by asking study participants to randomly pick a card containing a login and password from a jar. These credentials were used to log into the system, which automatically assigned each participant to one of the four experimental groups as listed in Table 1. These cards were created ahead of time and equally split among each condition.

<table>
<thead>
<tr>
<th></th>
<th>High PERA</th>
<th>Low PERA</th>
</tr>
</thead>
<tbody>
<tr>
<td>High INQA</td>
<td>Group1</td>
<td>Group3</td>
</tr>
<tr>
<td>Low INQA</td>
<td>Group2</td>
<td>Group4</td>
</tr>
</tbody>
</table>

**Note.** PERA: perceptual arousal. INQA: inquiry arousal.
This study used a web-based software framework as a delivery method for electronic multimedia pages containing two informational text topics with an embedded pedagogical agent, and as a data-gathering tool. The text passages were chosen specifically to control for content-based triggering of situational interest, which should be mostly affected by the design of the animated pedagogical agent. This was achieved by an earlier survey with different students from the same program, which measured their level of perceived interest on 12 different topics. The two lowest scoring texts were then selected for this study. The use of two shorter topics instead of a single one further reduced the possibility of personal interest becoming a significant extraneous variable, as it should even out any effect of prior personal interest or topic knowledge across the entire experiment.

Two types of arousal were manipulated in the design of pedagogical agent. The high PERA design relied on graphics, animation, voice, sound, and other perceptual factors, while high INQA design focused on the content provided by the agent, which consisted of questions, paradoxes, or challenges. The low PERA and INQA designs attempted to minimize both arousal conditions as described in Chapter 3. The text material remained identical for all of the four conditions.

This experiment used posttests to measure situational interest, perceived cognitive loads, and reading comprehension. A six-item measure which loaded on a single latent factor of situational interest, developed and validated by Rotgans and Schmidt (2009, 2011a, 2011b), was used. The cognitive load was measured with an 11-item Likert-scale questionnaire based on intrinsic, extraneous, and germane load components (Leppink et al., 2013). Finally, reading comprehension was assessed using the multiple-choice questions which were included in the original text reading materials.
Summary

The role of interest in education and the effectiveness of pedagogical agents in supporting educational goals are well established among the educational research community. At the same time, the increasing popularity of technology-based multimedia devices in U.S. culture is recognized as an important factor in shaping student identities in the 21st century, and also raises many questions about the potential role of multimedia in reading and learning in general. Unfortunately, research to guide multimedia text designs with pedagogical agents is still in its infancy, which is the main impetus for this experimental study. The next chapter will review prior research and foundational theories that support the premise that multimedia reading tasks with integrated pedagogical agents can be effectively used to trigger situational interest, increase generative processing, and improve reading comprehension.
CHAPTER TWO: LITERATURE REVIEW

According to Electronic Software Association 2015 report, about half of Americans play video games, with the number of players steadily increasing (ESA, 2015). New computer technologies, which enable modern computer games, along with mobile devices and social networks, promote different types of literacies and provide seductive alternatives to reading. Recreational reading among 6th grade and older students in Western industrialized nations declines substantially compared to their younger peers (OECD, 2010; Mol & Bus, 2011). This presents a dilemma for many educators since reading comprehension is instrumental in learning from textual materials and recreational reading is known to be an important factor in developing and maintaining this type of literacy (Share, 2008; Cox & Guthrie, 2001). The American public K-12 and higher education system relies heavily on textbooks, and much of the knowledge today is stored in textual (electronic or hard copy) form. Although many students in the digital age are proficient readers, they often struggle with reading comprehension, partially due to a low interest in reading (Renninger & Hidi, 2011; Schraw & Lehman, 2001). This, in turn, often correlates with diminished individual academic and professional success (Gottfried, Schlackman, Gottfried, & Boutin-Martinez, 2015; Mol & Bus, 2011; Notten, 2011; OECD, 2010; Taylor, 2013).

Interest plays an important part in learning from texts since it determines in part what we choose to learn and how we learn the textual information (Alexander & Jetton, 1996; Garner, 1992). For example, experiments have shown that more interesting stories use different types of recall encoding and require fewer attentional resources for comprehension than less interesting stories (McDanniel et al., 2000). There have been many attempts to make textual materials
embedded in school subjects more interesting to students. Some approaches, for example, suggested using contextually rich texts which are personally relevant (Klassen, 2006; 2009) or historically accurate (Clough, Herman & Smith, 2010) in science education. However, it is not always possible to produce intrinsically interesting texts for all school topics, which begs the following question: *How can we utilize new multimedia technologies to make the existing texts more interesting to readers?* One possible solution is to insert short, intrinsically motivating games between electronic text pages, which require a certain level of reading comprehension to advance to the next page (Smith et al., 2013). Another promising approach uses multimedia texts with embedded pedagogical agents with voice narration to increase student situational interest and reduce perceived cognitive load (Park, 2015). It may be possible that traditional texts could benefit from the affordances of the modern multimedia environments. However, it is not clear how such hybrid systems should be designed to manage the cognitive load while at the same time triggering and promoting situational interest in the text content. This literature review will focus on situational interest and attention arousal theories that provide support for multimedia text learning with pedagogical agents and expose possible gaps in knowledge in this area of instructional technology.

**Pedagogical Agents**

The use of animated pedagogical agents (APA) designed to facilitate learning in multimedia environments has increased as new technologies have made them more feasible (Gholson & Craig, 2002; Johnson, Rickel, & Lester, 2000). With the more recent introduction of mobile devices and improvements in data network technologies, these environments are becoming increasingly more accessible, which underlines their potential for use in learning. Multimedia can be defined as a presentation of both words (such as spoken or printed text) and
pictures (such as illustrations, photos, animation, or video) (Mayer, 2009). It provides a natural setting for pedagogical agents, which can be defined as computer characters embodied with speech, gestures, or movements (Sweller, Ayres, & Kalyuga, 2011). Pedagogical agents can employ different pedagogical approaches, including but not limited to supplanting, scaffolding, coaching, testing, demonstrating, or modeling a procedure (Schroeder & Adescope, 2014). In multimedia learning with pedagogical agents embedded in textual materials, learners can simultaneously access information through working memory from multiple sources (i.e., graphics, text, and audio), hence the designation "multimedia texts." Pedagogical agents are known to promote learning from textual materials by increasing germane cognitive load through generative processes based on multimedia design principles (Mayer, 2014; Park, 2015). Theoretical support for pedagogical agents is rooted in cognitive load theory (CLT), cognitive theory of multimedia learning (CTML) and cognitive affective theory of learning with multimedia (CATLM).

**Cognitive Load Theory**

According to cognitive load theory (CLT), a human brain utilizes two types of memory—the working memory and long-term memory—to process, store, and access information (Paas & Sweller, 2014; Sweller, Ayres & Kalyuga, 2011; Sweller, van Merriënboer & Paas, 1998). Working memory has a limited capacity, and the effectiveness of instructional materials is known to be affected by cognitive loads inherent in their designs. There is a general agreement among researchers that there are three types of cognitive loads: (a) intrinsic cognitive load, (b) extraneous cognitive load, and (c) germane cognitive load. Intrinsic cognitive load is found in any type of instruction and can be manipulated by adjusting the learning tasks and information presented. Extraneous cognitive load is a result of ineffective instructional designs and can be
minimized by following known multimedia design principles. Germany cognitive load is also imposed by instructional design, but it improves the effectiveness of learning instruction by stimulating affective variables such as situational interest or curiosity, which are known to impact learning (Kalyuga, 2010; Plass, Moreno, & Brünken, 2010).

**Cognitive Theory of Multimedia Learning**

The cognitive theory of multimedia learning (CTML) proposed by Richard Mayer is a constructivist theory of learning based on the dual coding theory (DCT) first suggested by Allan Paivio (1971) and the CLT. It states that people learn from words and pictures by processing two separate (verbal and visual) channels, that each channel can process limited information at the same time, and that meaningful learning requires engagement in appropriate cognitive processing during learning (Mayer, 2009, p.57). The *dual-channel, limited-capacity*, and *active-processing* assumptions form the foundations of the CTML. Richard Mayer applied the three types of cognitive loads mentioned in the previous section to designing multimedia learning environments when he suggested three types of cognitive processing demands present in CTML: essential processing, extraneous processing, and generative processing. The summary of the relationships between CLT cognitive load types and CTML cognitive processing demands is presented in Table 2 (Mayer, 2014).
Table 2. Three Demands On Cognitive Capacity During Multimedia Learning.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Caused by Learning process</th>
<th>Example</th>
<th>Cognitive Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraneous processing</td>
<td>Cognitive processing that is not related to the instructional goal</td>
<td>Poor instructional design</td>
<td>Focusing on irrelevant pictures</td>
<td>Analogous to extraneous cognitive load</td>
</tr>
<tr>
<td>Essential processing</td>
<td>Cognitive processing to represent the essential presented material in working memory</td>
<td>Complexity of the material</td>
<td>Memorizing the description of essential processing</td>
<td>Analogous to intrinsic cognitive load</td>
</tr>
<tr>
<td>Generative processing</td>
<td>Cognitive processing aimed at making sense of the material</td>
<td>Motivation to learn</td>
<td>Explaining generative processing in one’s own words</td>
<td>Analogous to germane cognitive load</td>
</tr>
</tbody>
</table>

In his early work on multimedia learning, Richard Mayer stressed the significance of emotions and seductive details in potentially undermining the learning effectiveness of multimedia materials (Mayer, 2009). He argued that emotional interest is supported by arousal theory, which states that students learn better when they are emotionally aroused by the material (Kintsch, 1980; Weiner, 1990). According to Mayer, this is based on an outmoded view of learning as knowledge transmission—the idea that learning involves transfer or knowledge from teacher to a student (Mayer, 2009). When viewed through a constructivist lens of learning—the idea that students build mental representations of the new material based on their prior knowledge—the seductive details are likely to interfere with the process of knowledge construction (i.e., selecting relevant information, linking it with the incoming visual information, organizing this information into a coherent structure, and integrating the material with existing knowledge) due to a limited cognitive capacity of short-term sensory memory. Mayer’s coherence principle states that people learn more deeply from a multimedia message when extraneous material is excluded rather than included (Mayer, 2009, p. 97). There are three possible explanations for the coherence effect. First, the presence of seductive details may direct
student’s attention away from the relevant material. Second, introduction of seductive details within the explanation may disrupt the ability to build a cause-and-effect chain or other mental models to represent the new information. Third, the students may assume that the theme of the content comes from seductive details and may try to integrate these details into the learning content (Mayer, 2009, p. 95). Because of the coherence principle, it is important to distinguish between details irrelevant to the learning objectives, which contribute to extraneous cognitive load, and those that support the learning objectives and can contribute to generative processing.

Cognitive Affective Theory of Learning with Media

Although Mayer initially argued against the use of interesting words, pictures, music, and sounds in multimedia learning since they may interfere with the sense-making process (Mayer, 2009, p. 95), Moreno later incorporated motivational and metacognitive factors as mediators of multimedia learning into CTML and proposed the cognitive-affective theory of learning with media (CATLM; Moreno 2005, Moreno & Mayer, 2007). CATML is based on a number of assumptions: a) humans have separate channels for processing different information modalities; b) only a few pieces of information can be actively processed at any one time in working memory within each channel; c) meaningful learning occurs when the learner spends conscious effort in cognitive process such as selecting, organizing, and integrating new information with existing knowledge; d) long-term memory consists of a dynamic, evolving structure which holds both a memory for past experiences and a memory for general domain knowledge; e) motivational factors mediate learning by increasing or decreasing cognitive engagement; f) metacognitive factors mediate learning by regulating cognitive processing and affect; and g) differences in learners’ prior knowledge and abilities may affect how much is learned with specific media (Moreno & Mayer, 2007).
Research evidence supports the benefits of instructional designs based on CATLM design principles which increase learners’ motivation and improve learning outcomes by increasing generative processing (Heidig et al., 2014; Mayer & Estrella, 2014; Plass et al., 2012; Um et al., 2011). There have been a number of studies focusing on generative processing which manipulated germane cognitive loads (e.g., Berthold & Renkl, 2009; Gerjets & Hesse, 2004; Renkl, Atkinson, & Große, 2004). Some studies examined the learning effect of combining strategies to reduce extraneous load while increasing germane load to redirect subjects’ cognitive resources from distracting to relevant schema acquisition activities (Seufert & Brünken, 2006; Seufert, Jänen, & Brünken, 2007). However, little research has been conducted on the strategies for generative cognitive processing aimed to foster germane cognitive load in pedagogical agent multimedia learning. One notable exception includes a recent study of the effects of social cue principles on cognitive load, situational interest, motivation, and achievement (Park, 2015), but this experiment did not look at different arousal conditions in pedagogical agent designs, nor at their impact on different cognitive loads.

The affective mediation assumption of CATLM proposes that motivational factors affect learning by increasing or decreasing cognitive engagement. Generative underutilization occurs when a learner has cognitive capacity available for generative processing but does not exert the effort to engage in learning due to insufficient interest to engage in germane cognitive activities (Mayer, 2014). The role of pedagogical agents is to optimize generative utilization. Well-designed pedagogical agents take advantage of the tenets of CLT, CTML, and CATLM design principles by increasing interest and motivation through generative cognitive processing without affecting the intrinsic and extraneous cognitive loads. This interaction is illustrated in Figure 1.
Figure 1. Pedagogical Agent Multimedia Learning Design Model.

**Situational Interest**

The modern study of interest in education has its roots in Dewey’s (1913) classic work *Interest and Effort in Education*. Dewey believed that interest in the context of learning is fundamentally different from effort. He argued that although effort was important, it did not alone promote what we today refer to as “deep learning.” In fact, he suggested that “the appeal to sheer effort amounts to nothing” without interest (Dewey, 1913). Despite these important insights, there was a period of over 50 years after Dewey’s publication with very little research in this area. This lull was probably caused by the period of American Behaviorism, which was typically adverse to unobservable psychological constructs such as interest (Schraw & Lehman,
It was not until the 1970s that the advent of prose learning theory and research on story grammars invigorated research on interest. Kintsch (1980) was among the first to explicitly address the relationship between interest and text processing by distinguishing between emotional and cognitive interests. He hypothesized that cognitive interest would be most strongly related to text comprehension when interest was moderately high, while low levels of cognitive interest led to a feeling of boredom (Schraw & Lehman, 2001). Even though the constructs of emotional and cognitive interest had not been tested empirically, they provided conceptual bases for future work in the area of interest development.

In 1983, Van Dijk and Kintsch proposed a highly influential text-processing theory with empirical evidence which held that interest was related to comprehension of a text’s macropropositional structure (i.e., thematic main ideas), but also that inclusion of information that was interesting, but not central to the text’s macrostructure, interfered with the recall of important macropropositional segments. This effect is referred to today as “seductive details” (Schraw & Lehman, 2001). Around the same time, the idea of interest-based parsing was introduced by Roger Schank, who stipulated that interest is essential to the strategic allocation of limited cognitive resources. This idea would later evolve into the theoretical foundations of cognitive load theory (Schraw & Lehman, 2001). Other research in this period had shown that grade-school children learned more information when it was judged as highly interesting, possibly because interest provided incentive to selectively attend and process the information when initial motivation was low (Asher, 1980); that changes in text structures affected interest ratings, but did not necessarily affect learning from text (Hidi & Baird, 1988); and that preschoolers shifted their attention on the basis of personal and gender-related interests, suggesting that personal interest was related strongly to prior knowledge (Renninger & Wozniak,
Collectively, these studies indicated the following central points about situational interest: a) it was related to attention and learning, b) it varied from person to person, and c) it was affected by factors such as prior knowledge, unexpected text content, text structure, and reader goals (Schraw & Lehman, 2001). However, it was not until the 1990s when a systematic conceptualization of interest started to emerge.

One of the main misconceptions about interest among many educators in the past was a belief that interest in general was a stable construct of vocational nature, and that there was little that teachers could do to develop a student’s academic interests (Lipstein & Renninger, 2006). Such beliefs were partially supported by the fact that prior to the 1990s there was very little empirical research that dealt with interest development. This view started to change with the publication of *The Role of Interest in Learning and Development* (Renninger, Hidi, & Krapp, 1992). In this influential publication, the authors formally identified two categories of interest: personal (a.k.a. individual or topic interest) and situational interest. Personal interest refers to content-specific information of enduring personal value that is activated internally with basis in pre-existing knowledge, personal experience, and emotions (Renninger, Hidi, & Krapp). In addition, personal interest can be categorized as latent and actualized, with latent interest further subdivided into feeling-related and value-related interests (Schiefele, 1992). Situational interest, on the other hand, is defined as information that is content-specific, spontaneously and environmentally activated, and of temporary value. The research on situational interest can be categorized as (1) text-based research, which deals with properties of text; (2) task-based research and changes in coding instructions of readers’ goals; or (3) knowledge-based research, which deals with interest that is generated due to relevant prior knowledge (Schraw & Lehman, 2006). A taxonomy of interest based on Schraw and Lehman can be seen in Figure 2.
The construct of situational interest was recently validated with a Latent-State Trait analysis of 327 high school students during problem-based learning activities. Researchers discovered that substantial proportions of situational interest variance were situation-specific and unrelated to initial individual interests (Knogler et al., 2015). This finding gives additional credence to the idea that situational interests can be successfully triggered regardless of existing personal interests.

In 2006, Hidi and Renninger proposed a four-phase model of interest development which views interest as a dynamic, affective construct consisting of distinct situational and individual factors that can evolve over time with proper stimuli and guidance (Hidi & Renninger, 2006). This model became a cornerstone of many current conceptualizations of interest and a starting point for a number of studies in this area. In this model, situational interest is defined as “focused attention and an affective reaction that is triggered in the moment by environmental stimuli, which may or may not last over time” (Hidi & Renninger, 2006, p.113). This definition specifically distinguishes situational interest from individual interest, which is viewed as more stable and persistent. According to Hidi and Renninger, personal interest is “[a] person’s relatively enduring predisposition to reengage [with] particular content over time as well as the
immediate psychological state when this predisposition has been activated” (Hidi & Renninger, 2006, p.113). As situational interest is “triggered” in phase one by environmental stimuli, and successfully maintained in phase two, it may eventually transform into emerging, and finally into a fully developed personal interest. The four phases of interest development are summarized in Figure 3.

Figure 3. Four-phase Model of Interest Development.

According to this developmental model, personal interest always starts as situational interest, which must be triggered by an external stimulus. This initial stimulus can take on many different forms. The attention phase of the ARCS model of motivational design identifies two arousal conditions—perceptual and inquiry—that may be examples of types of stimuli that trigger situational interest.

**ARCS Model of Motivational Design**

In instructional technology circles there has been much talk about motivational attributes and techniques of effective instruction. Central to that discussion was the historically behaviorist model known as Gagne's nine events of instruction, which provided a foundation for future motivational theories. Perhaps the most influential motivational model of instructional design consisting of *attention, relevance, confidence and satisfaction* is ARCS (although it was recently expanded to include a subcategory of violation as ARCS-V (Nakaima et al., 2014)). It has been used since the late 1980s in development of many instructional interventions and is based on the principles that instructional technology solutions should first attempt to gain students’ attention,
establish relevance of the material, build confidence through development of competence, mastery, and self-efficacy, and finally, promote satisfaction (Keller, 1987; 2009).

Table 3. ARCS Model Categories and Definitions.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>Capturing the interest of learners; stimulating the curiosity to learn</td>
</tr>
<tr>
<td>Relevance</td>
<td>Meeting the personal needs/goals of the learner to effect a positive attitude</td>
</tr>
<tr>
<td>Confidence</td>
<td>Helping the learners believe/feel that they will succeed and control their success</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>Reinforcing accomplishment with internal and external rewards</td>
</tr>
</tbody>
</table>

**Interest and Attention**

The ARCS model is based on the *emotions as facilitators of learning* hypothesis, which suggests that experiencing positive emotions during the learning process can enhance learning outcomes through mediating variables such as interest and motivation (Keller, 2009). Attention is necessary for both motivation and learning. The research in this area is primarily concerned with ways to stimulate and sustain learners’ attention, and then ways to direct it to the concepts, rules, skills, or facts to be learned. Attention has been linked to interest in a number of research studies (Ainley, Hidi, & Berndorff, 2002; Heidi, Renninger, & Krapp, 2004; McDaniel, Waddill, Finstad, & Bourg, 2000), and the attention category of ARCS aims to catch learners’ interest (Nakaima, 2014). As such, situational interest can be viewed as “triggered attention.” In the context of ARCS, the term “attention” is a synthesis of arousal theory, curiosity, boredom, and sensation seeking (Keller, 2009, p.76).

**Arousal Theory**

Arousal theory explains how behavior is activated and how it changes along with changing arousal levels as depicted in Figure 4. Much of the prior research on arousal was focused on physiological changes that occur during moments of calm or stress in human beings.
(Keller, 2009, p.76). In those studies, although arousal was considered to be a linear construct, the resulting changes in motivation and performance followed an inverted-U curve, where low levels of arousal were associated with low levels of performance, extending through a phase of optimal arousal and performance, to a decline in performance resulting from excessive stress (Keller, 2009, p. 76).

![Performance Under the Arousal Theory](image)

**Curiosity**

The second conceptual building block of attention is curiosity. There is a number of perspectives on the source and meaning of curiosity. The first perspective is *drive theory*, which assumes that curiosity is a state of arousal that can be aversive or unpleasant, resulting in an exploratory behavior aimed at resolving the situation that led to curiosity arousal. Daniel Berlyne (1954), who extensively studied curiosity, suggested that novelty and unexpected stimuli can activate a curiosity drive resulting in exploratory behavior until the stimulus is no longer
perceived to be novel. He proposed a *trigger-maintenance* model known as the *knowledge-deprivation hypothesis*. This hypothesis suggests that the emergence of situational interest is correlated with “epistemic curiosity,” which comes from the gap in knowledge between what is required and what is known about the topic. As the “thirst for knowledge” is “quenched,” this hypothesis suggests that situational interest will diminish, which was shown in recent studies (Rotgans & Schmidt, 2014). Accordingly, if no gap is perceived in the first place, then situational interest may not get triggered at all. Since prior knowledge can be a confounding variable, this is a reason for selecting contexts that are relatively unknown to research subjects in studies involving situational interest. Berlyne (1954) also distinguished between two different types of curiosity: perceptual curiosity, which focuses on a specific object and is information seeking; and epistemic curiosity, which corresponds to Keller’s perceptual and inquiry arousals.

The second perspective on curiosity, the *incongruity theory*, assumes that curiosity comes from perceived incongruities in an environment, which can be pleasant but tend to be aversive. According to Kagan (1972), the desire to remove uncertainty is the motive, but since it is not part of any tension reduction process it is not considered to be a “drive.” This idea is supported by Festinger’s (1957) work on cognitive dissonance, as well as by Gestalt psychology (Keller, 2009, p. 80). Cognitive dissonance is an aversive state of mind which activates a motive to eliminate the incongruity by removing the cause of discrepancy or by modifying one’s cognitive interpretations of the situation. Gestalt psychology is based on an assumption that the fundamental human motive is to make sense of the world. Its founding father, Max Wartheimer, and his followers have demonstrated that the whole can be different than the sum of its parts due to human tendencies to close gaps by organizing their perceptions into meaningful and familiar
patterns and shapes. Both research on cognitive dissonance and Gestalt psychology provide support for the incongruity theory of curiosity.

The third perspective views curiosity as a human characteristic related to the desire to achieve mastery of one’s environment. This idea is also based on a human motive rather than a drive, and is supported by research by Maw and Maw (1964), who suggested that curiosity is a positive quest for knowledge and information that will answer questions, lead to deeper levels of understanding, and increase one’s level of competence and mastery (Keller, 2009, p.81). Unlike the drive and incongruity theories, this third perspective does not presume that an aversive state of mind is a prerequisite of curiosity. Regardless of their differences, drive, incongruity, and competence form strong theoretical foundations for curiosity inducing instructional designs.

**Boredom and Sensation Seeking**

Another component of the attention model is boredom, which is considered to have an inverse correlation with arousal, while monotony, defined as repetitiveness, is known to be positively correlated to boredom. In addition, past research has shown that low arousal, high constraint, and high unpleasantness are very closely associated with boredom (Geiwitz, 1966). Boredom can also be viewed as a state of mind below one’s optimal level of stimulation (Keller, 2009, p. 90). In contrast, sensation seeking is defined as the extent to which people seek unusual or novel experiences (Zuckerman, 1979). Sensation seeking is based on a motive to satisfy one’s desires for novelty, change, and excitement, and may include various forms of physically challenging activity, emotionally engaging entertainment, or high levels of social activity (Keller, 2009, p. 91). The research on boredom and sensation seeking suggests that people vary in the amount of stimulation that is optimal; for example, an instructional pace that is considered relaxing by a person who is low in arousal needs may be boring to a person high in sensation...
needs. This is one of the reasons why audience analysis and variation in instructional approaches is important in motivational design studies (Keller, 2009, p. 92).

**Tactics to Trigger Attention**

Keller has linked Berlyne’s concept of perceptual and epistemic curiosity to perceptual and inquiry arousal conditions of attention. He also incorporated the issues of boredom and sensation seeking under the label of variability. Therefore, in the context of the ARCS model, attention can be subdivided into three types of stimuli: (a) perceptual arousal, (b) inquiry arousal, and (c) variability. Perceptual arousal (PERA) is often related to spontaneous curiosity which can be triggered by reflexive reactions to stimuli (Berlyne, 1965; Keller, 2009), while inquiry arousal (INQA) can be defined as a deep curiosity resulting from incongruent, conflicting, or incomplete cognitive inputs which can only be resolved by knowledge seeking behavior (Keller, 2009, p.47). The variability (in stimulus characteristics) is not considered a trigger condition for situational interest, but is instead a maintenance attribute of attention and will not be examined in his study. Table 4 summarizes tactics and design variables used in Chapter 3 to guide the development of animated pedagogical agents, which focus on PERA and INQA conditions.

Table 4. Attention Arousal Tactics and Design Variables.

<table>
<thead>
<tr>
<th>Type of Arousal</th>
<th>Supporting Tactics</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERA (Capture interest based on drive)</td>
<td>Create curiosity and wonderment by using novel approaches, injecting personal and/or emotional material.</td>
<td>Collative variables such as novelty, change, surprisingness, visual incongruity, complexity, visual ambiguity, indistinctness.</td>
</tr>
<tr>
<td>INQA (Stimulate an attitude of inquiry based on motive)</td>
<td>Increase curiosity by asking questions, creating paradoxes, generating inquiry, and nurturing thinking challenges.</td>
<td>Cognitive incongruity (cognitive dissonance i.e., conflict &amp; uncertainty), cognitive ambiguity.</td>
</tr>
</tbody>
</table>

Note. *PERA: perceptual arousal. INQA: inquiry arousal.*
Instructional Design

Instructional technology (IT) is a field concerned with improving the efficiency and effectiveness of pedagogical instruction. It focuses on the design process of instruction based on learning theories and their implementation using modern tools, such as computers or mobile devices. In terms of design methodologies in IT, the most common approach is known as the ADDIE model (Reiser & Dempsey, 2011). This model consists of 5 steps: analysis, design, development, implementation, and evaluation, with possible iterative loops between evaluation and design stages as depicted in Figure 5.

![ADDIE Model](image)

This research study used materials developed in a similar fashion, through a repetitive evaluation and revision process of designs informed by a number of multimedia and emotional design principles, as well as by Keller's ARCS motivational model of instruction.

Multimedia Design Principles

A number of research studies tested CTML assumptions, strategies, and techniques, and as a result, Mayer has proposed several design principles for managing each cognitive load and processing demand (Mayer, 2014a). To reduce extraneous loads, for example, instructional designs should follow the coherence principle, signaling principle, redundancy principle, spatial contiguity principle, and temporal contiguity principle. For managing intrinsic loads, multimedia instruction should incorporate the segmenting principle, pre-training principle, and
modality principle. To foster germane cognitive load, Mayer recommended following the multimedia principle, personalization principle, voice principle, and embodiment principle (Mayer, 2014a).

**Extraneous Processing Management**

Limiting extraneous processing is important in effective multimedia designs, and the coherence principle states that extraneous materials should be excluded from the presentation since 1) learning is improved when interesting but irrelevant words and pictures are excluded from multimedia presentations; 2) learning is improved when interesting but irrelevant sounds and music are excluded from multimedia presentations; and 3) learning is improved when unneeded words and symbols are eliminated from a multimedia presentation (Mayer, 2009, p. 89). In addition, multimedia designers should consider adding cues that highlight the organization of essential material, as suggested by the signaling principle, since signaling reduced extraneous cognitive processing by guiding the learner’s attention to the key elements in the lesson (Mayer, 2009, p. 108). The redundancy principle states that people learn better from graphics and narration than from graphics, narration, and printed text, since redundant information creates extraneous processing a) because the visual channel can become overloaded by having to visually scan between pictures and on-screen text, and b) because learners expand mental effort in trying to compare the incoming streams of printed and spoken text (Mayer, 2009, p. 118). The spatial contiguity principle simply states that students learn better when corresponding words and pictures are presented near each other on the screen since students do not have to use additional cognitive resources to visually search for them and are more likely to keep both of them in working memory at the same time (Mayer, 2009, p. 135). Finally, the temporal contiguity principle states that students learn better when corresponding words and
pictures are presented simultaneously since they are more likely to hold mental representations of both in working memory at the same time (Mayer, 2009, p. 153).

**Essential Processing Management**

For managing intrinsic cognitive loads, Mayer suggested following the *segmentation principle* which states that people learn better when multimedia messages are presented in user-paced segments; for example, upon viewing a fast-paced multimedia presentation which explains some process in a series of steps, some learners may not fully comprehend one step before the next is presented, and thus they may not be able to see the causal relationship between steps (Mayer, 2009; p. 175). Next, the *pre-training principle* simply states that people learn more deeply in multimedia environments when they know the names and characteristics of the main concepts. When viewing a fast-paced multimedia presentation, viewers have to mentally construct a causal model of the system (i.e., how things work), as well as the component model of the system (i.e., model of the states each component can be in), and pre-training can offload some of this cognitive processing to a pre-training episode (Mayer, 2009, p. 189). Finally, the key *modality principle* states that people learn more deeply from pictures and spoken words than from pictures and printed words. The support of this principle comes from the dual-coding theory and limited-capacity assumption in visual cognition. Simply stated, if both pictures and words enter through the same cognitive channel (the eyes), they can cause an overload in the visual system. If the words are off-loaded onto the verbal channel, the learner will have more capacity to fully process the pictures in the visual channel (Mayer, 2009, p. 200).
Generative Processing Management

In order to improve the germane processing in multimedia environments, the multimedia principle, which states that people learn from words and pictures better than from words alone, should be followed. The theoretical rationale for educational multimedia texts is that when words and pictures are both present, learners have an opportunity to construct verbal and visual mental models and to build connections between them. When only words are presented, the learners are less likely to build a corresponding visual model (Mayer, 2009, p. 223). The personalization principle states that people learn better from multimedia when words are in conversational rather than formal style. This is based on the research which suggests that when learners feel that the author is talking to them, they are more likely to see that author as a conversational partner, and therefore will try harder to make sense of what the author is saying (Mayer, 2009, p. 242). The voice principle is that people learn more deeply when the words in multimedia message are spoken by a friendly human voice rather than by a machine or mechanical-sounding voice (Mayer, 2009, p. 255). The embodiment principle states that people learn more deeply when a pedagogical agent embedded in multimedia environment presents human-like gesturing, movement, eye contact, and facial expressions (Mayer, 2014a).

Additional Design Principles

Moreno and Mayer acknowledged the importance of interactivity in designs based on the CATML theoretical model and also proposed a number of relevant instructional constructs: guided activity, reflection, feedback, control, and pre-training (Moreno & Mayer, 2007). Mayer later expanded these ideas into additional multimedia design principles: the guided discovery principle, the self-explanation principle, and the drawing principle (Mayer, 2014a). The guided discovery principle states that guidance should be given to students to ensure effective learning
during scientific discovery in multimedia environments. What this means is that the learning content should not be directly presented but needs to be constructed by the student, which is the very essence of scientific discovery learning (Mayer, 2014a, p. 372). According to Mayer, the self-explanation principle suggests that people will learn more from multimedia environments if they contain constructive or generative learning activities that facilitate deep and robust learning by encouraging students to make inferences using learning materials, identify previously held misconceptions, and repair mental models (Mayer, 2014a, p. 413). Finally, the drawing principle proposes that asking students to create drawings while reading text causes generative processing that leads to better learning outcomes (Mayer, 2014a, p. 433). However, this study will not explore interactive design principles as it focuses mainly on correlation between situational interest and arousal conditions found in emotional aspects of non-interactive agent presentation and their possible effect on generative processing.

Summary

Situational interest is an important psychological construct that can affect reading comprehension and the effectiveness of instructional environments containing textual materials. In recent years, a number of studies have shown that multimedia instructional designs supported by CLT, CTML, and CATLM theoretical models provide an effective way of improving learning outcomes. According to CTML, pedagogical agent designs, which promote generative processing, should be based on the multimedia principle, personalization principle, voice principle, and embodiment principle. Research in this area also suggests that any ARCS model attention arousal triggers must be relevant to learning objectives and contribute to the generative processing involving: 1) selecting and linking, 2) organizing new information into coherent structures, and 3) integrating it with prior knowledge.
The primary goal of this research inquiry was to examine the effects of perceptual and inquiry arousal conditions delivered by a pedagogical agent on English language learners' situational interests, cognitive loads, and comprehension in online English reading tasks. According to Keller, perceptual and inquiry arousal are triggers of attention, with higher arousal resulting in more attention (Keller, 1987), but it is not clear how they affect development of situational interest individually or in combination with one another. Guided by the above goal and research literature review, this study examined the following research questions and alternative hypotheses:

**Research Question 1 (RQ1):** What is the effect of perceptual arousal, presented by a pedagogical agent, on English language learners' situational interest, cognitive loads, and reading comprehension in online English reading tasks?

**Rationale for RQ1:** Animated pedagogical agents are becoming more common due to advances in hardware and software technologies (Gholson & Craig, 2002; Johnson, Rickel, & Lester, 2000). According to Keller's ARCS model of motivational design (Keller, 2009), perceptual arousal and inquiry arousal attributes of attention are instrumental in triggering situational interest (Hidi & Renninger, 2005). However, there are no published studies that specifically examine the effect of perceptual arousal, delivered by animated pedagogical agents, on development of situational interest among populations of English language learners. Pedagogical agents promote learning from textual materials by increasing germane cognitive load through generative processing (Park, 2015). Situational interest is linked to learning from text (Kintsch, 1980; Schraw & Lehman, 2001). However, any link between perceptual arousal delivered by the animated pedagogical agent, and germane cognitive load leading to improved learning outcomes based on active-processing assumptions of the cognitive theory of
multimedia learning has yet to be examined. Based on the arousal theory and the concept of perceptual curiosity (Keller, 2009), this research question explores a possible positive relationship between perceptual arousal, situational interest, and reading comprehension, along with germane cognitive load in a context of animated pedagogical agents by testing the following hypotheses:

Hypothesis 1 (H1): English language learners in the high-PERA condition will show significantly higher situational interest scores than English language learners in the low-PERA condition.

Hypothesis 2 (H2): English language learners in the high-PERA condition will report significantly higher germane cognitive load scores than English language learners in the low-PERA condition.

Hypothesis 3 (H3): English language learners in the high-PERA condition will show significantly higher reading comprehension scores than English language learners in the low-PERA condition.

Research Question 2 (RQ2): What is the effect of inquiry arousal presented by a pedagogical agent on English language learners' situational interest, cognitive loads, and reading comprehension in online English reading tasks?

Rationale for RQ2: Similar to RQ1, there are no published studies that specifically examine the effects of inquiry arousal delivered by animated pedagogical agents on development of situational interest among populations of English language learners. Since inquiry arousal is based on the concept of epistemic curiosity, and supported by drive and incongruity theories, it is likely that it will have a stronger effect on the outcome variables since inquiry arousal triggers
are likely to persist longer than those of perceptual arousal (Keller, 2009). This research question explores a possible positive relationship between inquiry arousal, situational interest, and reading comprehension, along with germane cognitive load in a context of animated pedagogical agents by examining the following hypotheses:

Hypothesis 4 (H4): English language learners in the high-INQA condition will show significantly higher situational interest scores than English language learners in the low-INQA condition.

Hypothesis 5 (H5): English language learners in the high-INQA condition will report significantly higher germane cognitive load scores than English language learners in the low-INQA condition.

Hypothesis 6 (H6): English language learners in the high-INQA condition will show significantly higher reading comprehension scores than English language learners in the low-INQA condition.

Research Question 3 (RQ3): Are there any interaction effects between perceptual arousal and inquiry arousal presented by a pedagogical agent on English language learners' situational interest, cognitive loads, and reading comprehension in online English reading tasks?

Rationale for RQ3: In addition to the rationale presented in RQ1 and RQ2, this research study looked at any interaction of perceptual and inquiry arousal based on the dual-channel, limited-capacity and active-processing assumptions of the cognitive theory of multimedia learning (Mayer, 2009). It is possible that perceptual and inquiry arousals in pedagogical agents interact with one another despite the fact that they are designed to use separate visual and auditory channels. Perceptual arousal is known to be short-lived (Keller, 2009; Berlyne, 1965)
but because of the limited cognitive capacity of the human brain (Sweller, van Merriënboer, & Paas, 1998), it may interfere with inquiry arousal if presented at the same time and during a cognitively challenging activity, such as reading. This research question examines any cross effects of perceptual and inquiry arousal conditions presented by pedagogical agents embedded in reading tasks, on situational interest, cognitive loads, and reading comprehension by testing the following hypotheses:

Hypothesis 7 (H7): There is a significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' situational interest scores.

Hypothesis 8 (H8): There is a significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores.

Hypothesis 9 (H9): There is a significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' reading comprehension scores.
CHAPTER THREE: METHOD

Introduction

A randomized 2x2 between subjects factorial design was used in this study to examine two types of attention arousal conditions integrated into animated pedagogical agents (APAs). The APAs were embedded in online text reading tasks presented to English language learners attending an English language program at a major southeastern US university. This study employed two independent variables: perceptual arousal (PERA) and inquiry arousal (INQA), each manipulated into two levels (high and low), and three dependent variables: situational interest (SI), cognitive load (CL) components, and reading comprehension (RC). A claim of complete absence of perceptual arousal conditions cannot be easily supported and therefore, high and low level designations were chosen instead of present and absent levels. These “high” and “low” designations are based on presence or absence of multimedia elements classified as “perceptual” or “inquiry” arousal inducing conditions, which are derived from Keller’s definition of attention.

Table 5. Summary of Experimental Variables.

<table>
<thead>
<tr>
<th>Independent Variable *</th>
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</thead>
<tbody>
<tr>
<td>IV1:PERA</td>
<td>Perceptual Arousal</td>
</tr>
<tr>
<td>IV2:INQA</td>
<td>Inquiry Arousal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DV1:SI</td>
<td>Situational Interest</td>
</tr>
<tr>
<td>DV2:CL</td>
<td>Cognitive Load</td>
</tr>
<tr>
<td>DV3:RC</td>
<td>Reading Comprehension</td>
</tr>
</tbody>
</table>

Note. * IV: independent variable. DV: dependent variable. PERA: perceptual arousal. INQA: inquiry arousal
Based on the proposed research questions and alternative hypotheses listed in Chapter 2, the following null hypotheses were tested in this experiment:

Null Hypothesis 1 (H₀₁): There is no significant difference in situational interest scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition.

Null Hypothesis 2 (H₀₂): There is no significant difference in reported germane cognitive load between English language learners in the high-PERA condition and the English language learners in the low-PERA condition.

Null Hypothesis 3 (H₀₃): There is no significant difference in reading comprehension scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition.

Null Hypothesis 4 (H₀₄): There is no significant difference in situational interest scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition.

Null Hypothesis 5 (H₀₅): There is no significant difference in reported germane cognitive load between English language learners in the high-INQA condition and the English language learners in the low-INQA condition.

Null Hypothesis 6 (H₀₆): There is no significant difference in reading comprehension scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition.

Null Hypothesis 7 (H₀₇): There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' situational interest scores.
Null Hypothesis 8 (H₀₈): There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores.

Null Hypothesis 9 (H₀₉): There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' reading comprehension scores.

Participants

The participants of this study constituted a convenience sample chosen from a population of adult (18 and up) international students attending an English language program at a large southeastern US university. Their ethnicity can be classified as mostly Arabic and Chinese with gender representation skewed toward males. Their English language proficiency levels were determined earlier by a standardized test administered by the program, and all students selected for this study were classified as Level 4 or higher, meaning that their English language proficiency was on level with U.S. high school students. According to the program's staff, since the study used random assignment with anonymous data collection, it would be very difficult to link any previous scores to individual students. They also stated that there should be little variance in individual English language proficiency within each level. The justification for using international students was based on the assumption that reading materials will present more of a challenge (by stressing the cognitive capacity) and result in higher intrinsic and more variable germane cognitive loads. A desired sample size for a two-way ANOVA with α=.05, medium effect size f=0.4 and power=.85 was determined using the power analysis to be 122 students (Faul et al., 2007, 2009). The inclusion criteria extended to all students who are capable of operating a personal computer. The exclusion criteria included students unwilling or unable to
participate in an experiment due to psychological or physical conditions, or those who have already participated in this activity as determined by the instructor or the researcher. By the end of the data collection phase, 159 English learners were recruited from 18 classes and attended 13 experimental sessions. One of the students never completed the activity and another student reported to be less than 18 years old, both of whom were subsequently removed from the resulting dataset \((n=157)\) by erasing their entire record from the SPSS input file before analysis.

The participants were randomly assigned to one of the four conditions. Table 6 describes the sample. The experiment journal and protocol documents are included in the Appendices.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Number of Participants</th>
<th>Gender</th>
<th>Age Group</th>
<th>Ethnicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-PERA, high-INQA</td>
<td>39 (24.84%)</td>
<td>Female: 17 (43.6%) Male: 22 (56.4%)</td>
<td>18-21: 11 (28.2%) 22-25: 16 (41%) &gt;25: 12 (30.8%)</td>
<td>Arabic: 19 (48.7%) Chinese: 13 (33.3%) European: 1 (2.6%) Japanese: 0 (0%) Korean: 1 (2.6%) other: 5 (12.8%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high-PERA, low-INQA</td>
<td>39 (24.84%)</td>
<td>Female: 13 (33.3%) Male: 26 (66.7%)</td>
<td>18-21: 16 (41%) 22-25: 14 (35.9%) &gt;25: 9 (30.8%)</td>
<td>Arabic: 23 (59%) Chinese: 12 (30.8%) European: 2 (5.1%) Japanese: 0 (0%) Korean: 1 (2.6%) other: 1 (2.6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low-PERA, high-INQA</td>
<td>39 (24.84%)</td>
<td>Female: 17 (43.6%) Male: 22 (56.4%)</td>
<td>18-21: 13 (33.3%) 22-25: 14 (35.9%) &gt;25: 12 (30.8%)</td>
<td>Arabic: 16 (41%) Chinese: 13 (33.3%) European: 0 (0%) Japanese: 1 (2.6%) Korean: 3 (7.7%) other: 6 (15.4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low-PERA, low-INQA</td>
<td>40 (25.48%)</td>
<td>Female: 17 (42.5%) Male: 23 (57.5%)</td>
<td>18-21: 14 (35%) 22-25: 17 (42.5%) &gt;25: 9 (22.5%)</td>
<td>Arabic: 19 (47.5%) Chinese: 14 (35%) European: 1 (2.5%) Japanese: 2 (5%) Korean: 0 (0%) other: 4 (10%)</td>
</tr>
</tbody>
</table>

Note.  
\(^a\) PERA: perceptual arousal. INQA: inquiry arousal.  
\(^b\) Total \(n = 157\).
To confirm the validity of random assignment, a Chi-square tests of independence were conducted between 4 condition and gender type, age group, and ethnicity. All expected cell frequencies were greater than five. There was no statistically significant association between 4 experimental conditions and gender type, $\chi^2(3) = 1.200, p = .753$. There was no statistically significant association between 4 experimental conditions and age groups, $\chi^2(6) = 2.247, p = .896$. There was no statistically significant association between 4 experimental conditions and types of ethnicity, $\chi^2(15) = 14.394, p = .496$.

**Procedures**

This research study employed a 2x2 between subjects factorial design with four randomly assigned groups. Each comparison group corresponded to one of the four agent design conditions: high-PERA and high-INQA, high-PERA and low-INQA, low-PERA and high-INQA, and low-PERA and low-INQA, as shown in Table 1.

The experiment took place over one-hour sessions during regularly scheduled classroom times of 18 different classes of approximately 10 students each. Both the instructor and the researcher were present during each session. After a brief introduction and disclosures, which included informed consent, student participants faced a computer with a set of headphones and were asked to authenticate using credentials they randomly selected from a jar containing login name and password cards. After signing in, they were presented with a title page asking them to wait for the signal to start the experiment.

In Part 1 of the experiment, participants were given approximately 20 minutes to complete a multimedia activity consisting of four text pages with embedded pedagogical agents. In Part 2 of the experiment, students were asked to complete situational interest, cognitive load, and reading comprehension measures. In addition, they were asked to enter their age, gender,
and native language. This section also included additional questions about their personal interests and prior knowledge about the topics of the American Revolution and the Civil War, as well as manipulation check items. Expected timings of each section, along with the final materials, were validated via a pilot study performed a few days prior to the experiments. The design of the experiment is depicted in Figure 6.

Agent Implementation

Central to this research study is a well-designed and implemented pedagogical agent. Iclone-6 software was used to create a life-like animated character with facial expressiveness and changing background details. The agent was designed and piloted in the fall, and then revised after being evaluated by faculty and students. Design and development of the agent followed the standard Analysis – Design – Development – Implementation – Evaluation (ADDIE) model of instructional software development. The agent design attempted to be content specific; that is,
both perceptual and inquiry arousal triggers were relevant to learning objectives, and the topic of the passage was appropriate.

**Perceptual Arousal Design Guidelines**

The PERA designs activate a person’s perceptual level of curiosity by any sudden or unexpected changes in the environment. As reviewed in Chapter 2, these conditions are based on Berlyne’s research on perceptual curiosity and his *collative* variables, which include novelty, change, surprisingness, incongruity, complexity, and indistinctness (Berlyne, 1965). Berlyne also referred to this type of reaction as “specific exploration,” which focuses on a single target such as background image, person, or voice. As soon as the source of perceptual arousal is uncovered or understood, its effect is likely to decay rapidly (Rotgans & Schmidt, 2014). PERA is considered a transitory curiosity since people are known to quickly adapt to these types of triggers (Keller, 2009, p. 48). To trigger perceptual arousal, the multimedia environment could produce changes in a background, novel gestures, or surprising voice intonation or incongruity, as depicted below.

---

**Figure 7. High Perceptual Arousal Design.**
Inquiry Arousal Design Guidelines

INQA is considered a deeper, longer lasting level of curiosity, which can only be resolved by knowledge-seeking behavior. Typical strategies for triggering INQA conditions include questions, creating paradoxes, generating inquiry, and nurturing thinking challenges (Keller, 2009). Unlike specific exploration of PERA condition, INQA is based on the concepts of diverse exploration and epistemic curiosity (Berlyne, 1965). In contrast to the PERA designs, the INQA design should create conditions which promote students' epistemic curiosity. In this experiment, the principal difference lies in the APA message itself, which in the INQA condition must contain a relevant and interesting question, paradox, or challenge, as depicted in Figure 9. The four questions selected for high-INQA conditions in this study were: "Do you know how long the American Revolutionary War lasted and what side the French generals were on? Was Cornwallis almost able to escape because of the bad weather, or was the weather responsible for
a decisive British defeat? What were the biggest problems facing prisoners of war during the American Civil War? Where was Andersonville located, and what did the prisoners eat?" The APA in low-INQA conditions simply said "Continue reading."

Figure 9. High Inquiry Arousal Design.
Mixed Condition Design Guidelines

This experiment contains four conditions (high-PERA, high-INQA; high-PERA, low-INQA; low-PERA, high-INQA; and low-PERA, low-INQA). This means that the design guidelines discussed above had to be applied together. For example, in the high-PERA, high-INQA condition the APA not only asked interesting questions, but it also appeared excited while the background contained relevant eye-catching visuals. In contrast, the low-PERA, low-INQA condition did not have any background at all, the APA hardly moved, while the message it delivered was only informative and devoid of any questions, paradoxes, or challenges.

Study Materials

The texts used in this study were selected based on faculty recommendations from a Timed Readings series of books by Jamestown Publishers (Spargo, 1980). Each book contains 50 four-hundred-word narratives covering a range of topics, each followed by 10 multiple choice
“recall” and “understanding” questions. To ensure that content selected for this experiment was not well known or interesting, 12 titles were picked from four books, along with a short content paragraph, and were presented to 26 students of similar demographics as the target sample during a summer session to evaluate their perceived interest and prior knowledge of the topic using a 10-point scale questionnaire (Appendix A). Of those, the two titles with the lowest average interest scores were chosen for this experiment (Appendix B). The selected text passages are: “The Surrender at Yorktown” (4.29 average interest score) and “Agony at Andersonville” (5.38 average interest score). One of the topics, “Busy Little Carpenters” scored lower than "Agony at Andersonville," but it was not selected because American history topics were deemed by the researchers to be more beneficial to international students. The actual titles were omitted in the experiment to limit students’ attention to the content of the texts, which were combined into a single 20-minute, four-page reading activity.

The web-based research software suite used in this study to deliver texts with embedded audio-visual media was created by a team of developers led by the author of this study using open-source technologies, which include MySQL database, PHP server side language, HTML5 with CSS3, XML, and JQuery Mobile. This software provides a technical framework which supports subject and investigator authentication/authorization, configurable research design, and data collection and reporting from central, secure server storage.

**Dependent Variables**

This study measured a number of variables, including situational interest (SI), cognitive loads (CL), and reading comprehension (RC)—in that order. An online questionnaire was employed to measure different, underlying constructs corresponding to the aforementioned dependent variables. One construct, “situational interest,” consisted of six questions. The scale
had a high level of internal consistency, as determined by a Cronbach's alpha of .854. Another measured construct was a ten-item “cognitive load” which consisted of three components: three-item “intrinsic cognitive load,” three-item “extraneous cognitive load,” and four-item “germane cognitive load.” The Cronbach’s alphas of each component were 0.83, 0.74, and 0.91, respectively. The last measured construct was “Reading Comprehension,” which consisted of 20 questions. This scale had a low level of internal consistency, as determined by a Cronbach’s alpha of .57. The reading comprehension questions came from the reading materials themselves, which were previously used and recommended by the English language program staff and are considered valid for the current population. The low reliability score might have been caused by the overall low English language proficiency of the sample population. In addition to the above constructs, the questionnaire contained four manipulation check questions, single self-reported items for prior interest and prior knowledge about the topics, as well as a number of questions designed to capture some limited gender, age, and demographic data. In addition, usage statistics including all key strokes and time spent by students on each page and in each instrument were collected by the software.

**Situational Interest**

The situational interest (SI) score was measured with the six-item scale adopted from Rotgans and Schmidt (2011b), as shown in Table 7. The items were scored on a 5-point Likert scale: 1 (not true at all), 2 (not true for me), 3 (neutral), 4 (true for me), and 5 (very true for me) with higher score indicating higher situational interest. The construct validity of the situational interest measure was established by means of confirmatory factor analysis (Byrne, 2001), and reliability of the instrument (Hancock’s coefficient H=.95) was also established in previous
studies (Rotgents & Schmidt, 2009). The wording of some of the items was slightly adjusted to better fit the content and the student population of this experiment.

Table 7. Situational Interest Scale.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Factor</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I_1</td>
<td>I want to know more about these topics.</td>
</tr>
<tr>
<td>2</td>
<td>I_2</td>
<td>I enjoyed reading about these topics.</td>
</tr>
<tr>
<td>3</td>
<td>I_3</td>
<td>I think these topics were interesting.</td>
</tr>
<tr>
<td>4</td>
<td>I_4</td>
<td>I expect to master these topics well.</td>
</tr>
<tr>
<td>5</td>
<td>I_5</td>
<td>I was fully focused on these topics.</td>
</tr>
<tr>
<td>6</td>
<td>I_6 a</td>
<td>I was bored.</td>
</tr>
</tbody>
</table>

*Note.* a Item 6 was reverse-coded.

The 4-item manipulation check immediately followed the SI measure to validate the level of each treatment condition. The items in the manipulation check verified the perceptions of background and of the agents’ acting, speech (PERA), and voice content (INQA), as depicted in Table 8.

Table 8. Manipulation Check Items.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The screen character had a) blank background, b) pictures related to the text. c) decorative background.</td>
</tr>
<tr>
<td>2</td>
<td>The screen character a) talked about the topic. b) only gave directions. c) didn't say anything.</td>
</tr>
<tr>
<td>3</td>
<td>The screen character a) acted excited. b) acted bored.</td>
</tr>
<tr>
<td>4</td>
<td>The screen character a) sounded bored. b) sounded excited.</td>
</tr>
</tbody>
</table>

**Cognitive Load**

The CL was measured with a 10-item Likert-scale questionnaire based on intrinsic, extraneous, and germane cognitive load components (Leppink et al., 2013), as shown in Table 9.

The cognitive load construct validity was established in previous studies involving populations
of graduate and undergraduate students, and reliability of the instrument was also established in prior studies with a Cronbach’s alpha of 0.81, 0.75 and 0.82 for each of the three components of the instrument: intrinsic, extraneous, and germane cognitive load factors (Leppink et al., 2013). The exact wording was adjusted from the original survey instrument to fit the content and the student population of this experiment.

Table 9. Cognitive Load Scale.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Factor a</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IL_1</td>
<td>The topics covered in the reading activity were very complex.</td>
</tr>
<tr>
<td>2</td>
<td>IL_2</td>
<td>The reading activity covered ideas that I perceived as very complex.</td>
</tr>
<tr>
<td>3</td>
<td>IL_3</td>
<td>The reading activity covered concepts and definitions that I perceived as very complex.</td>
</tr>
<tr>
<td>4</td>
<td>EL_1</td>
<td>The explanations during the reading activity were very unclear.</td>
</tr>
<tr>
<td>5</td>
<td>EL_2</td>
<td>The explanations were, in terms of learning, very ineffective.</td>
</tr>
<tr>
<td>6</td>
<td>EL_3</td>
<td>The explanations were full of unclear language.</td>
</tr>
<tr>
<td>7</td>
<td>GL_1</td>
<td>The reading activity really enhanced my understanding of the topics covered.</td>
</tr>
<tr>
<td>8</td>
<td>GL_2</td>
<td>The reading activity really enhanced my knowledge and understanding of the topics.</td>
</tr>
<tr>
<td>9</td>
<td>GL_3</td>
<td>The reading activity really enhanced my understanding of the ideas covered.</td>
</tr>
<tr>
<td>10</td>
<td>GL_4</td>
<td>The reading activity really enhanced my understanding of concepts and definitions.</td>
</tr>
</tbody>
</table>

Note. a IL: intrinsic cognitive load. EL: extraneous cognitive load. GL: germane cognitive load.

The items were scored on an 11-point Likert scale: 0 meaning not at all the case and 10 meaning completely the case, with higher scores meaning higher cognitive load. High intrinsic and extraneous cognitive loads are considered negative since they negatively affect learning outcomes, while high germane cognitive load is considered positive since it improves learning through generative processing (Mayer, 2014).
Reading Comprehension

The reading comprehension (RC) variable was evaluated with the publisher supplied multiple-choice questions (with three choices each) introduced at the end of each text passage (Appendix B). These questions were designed to evaluate readers' factual recall and understanding of the passage. In the context of this experiment, these questions were generalized as reading comprehension, since they only require lower order thinking of revised Bloom’s taxonomy, focusing on remembering and understanding of the factual and conceptual knowledge of the topic (Krathwohl, 2002). The validity assumption of this instrument was based on its publication status and instructors’ recommendations.

Data Analysis

The two independent variables were dichotomous, categorical variables. All three dependent variables were continuous, interval variables. The between group measures were compared using three 2-way between-subjects ANOVA (Kirkpatrick & Feeney, 2007; Field, 2013) using SPSS software. The preliminary analysis presented descriptive statistics and tested a number of assumptions. First, the experimental data set was processed, examined, and checked for any extreme outliers. Outliers are known to have a significant effect on the two-way ANOVA and can reduce the accuracy of results (Field, 2013). In addition to the above, the normal distribution assumption of dependent variables in each combination of groups was tested using the Shapiro-Wilk test for normality, though this assumption is not as critical since two-way ANOVA is quite “robust” to violations of normality (Field, 2013). Finally, the Levene’s test in SPSS was employed to verify homogeneity of variances for each combination of the groups of the two independent variables.
The main analysis was performed in SPSS using a series of two-way ANOVA on experimental data to examine the statistical significance of the two main and interaction effects of independent conditions (PERA and INQA) on each of the three dependent variables (SI, CL, and RC). Each null hypothesis was rejected or not rejected based on the outcomes. Null hypotheses $H_07$, $H_08$, and $H_09$ were tested first to determine any cross-interaction effects at $p < .05$ significance following any main effect of PERA and INQA on SI, CL, and RC, also at $p < .05$ level. The results are discussed in the next chapter.
CHAPTER FOUR: RESULTS

This research study examined the effects of perceptual and inquiry arousal conditions built into animated pedagogical agents on situational interest, cognitive loads, and reading comprehension in online reading tasks. It did so by testing the nine null hypotheses presented in Chapter 3. A 2x2 between-subjects factorial design was used with two levels of perceptual arousal and inquiry arousal conditions. Specifically, this study employed two independent variables with two levels, respectively: high/low perceptual arousal (PERA) and high/low inquiry arousal (INQA), and three dependent variables including situational interest (SI), cognitive load (CL), and reading comprehension (RC). Cognitive load was composed of three factors: intrinsic (CLI), based on the inherent difficulty of the material; extraneous (CLE), resulting from the ineffective instructional design; and germane (CLG), promoted by the instructional elements designed to stimulate affective variable. An online questionnaire was employed to measure different, underlying constructs corresponding to the aforementioned dependent variables. Table 10 summarizes calculated Cronbach’s reliability scores for all measures discussed in Chapter 3.
Table 10. Instrument Reliability.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Scale (Number of items)</th>
<th>Sample item</th>
<th>Internal consistency coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situational interest</td>
<td>6</td>
<td>I want to know more about these topics.</td>
<td>0.85</td>
</tr>
<tr>
<td>Cognitive load</td>
<td>Intrinsic (3)</td>
<td>The topics covered in the reading activity were very complex.</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Extraneous (3)</td>
<td>The explanations during the reading activity were very unclear.</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>Germane (4)</td>
<td>The reading activity really enhanced my understanding of the topics covered.</td>
<td>0.91</td>
</tr>
<tr>
<td>Reading comprehension</td>
<td>20</td>
<td>The American Revolution lasted almost seven years.</td>
<td>0.57</td>
</tr>
</tbody>
</table>

This study employed two independent, dichotomous variables and five dependent, continuous variables. The initial selection of classes for the sample was done by the English language program staff and included mostly Level 4, 5 and some Level 6 sections. In the following semester, the same course selection was used, but some of the continuing students had already participated in this study in the prior semester. To maintain the independence of observations, each class instructor explicitly asked their students if they had participated in this study before. In addition, at the beginning of each session the researcher asked the students again if they had done this activity already. A number of students were disqualified for that reason. Even though the study used different participants in each class who were randomly assigned to each of the four groups, some inter-subject communication between groups may have occurred prior to participation in experimental sessions. Experimental data analysis was performed using SPSS software version 24. For each dependent variable, the significance level for all the analyses was set at $p < .05$. Bonferroni adjustments were made when multiple comparisons were performed. The results of a series of five two-way ANOVA and other tests are reported in the following sections. Table 11 summarizes the findings for each null hypothesis.
Table 11. Summary of Null Hypotheses Analysis Results.

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Description</th>
<th>Analysis Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptual Arousal (PERA)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0^1$</td>
<td>There is no significant difference in situational interest scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition.</td>
<td>Not rejected.</td>
</tr>
<tr>
<td>$H_0^2$</td>
<td>There is no significant difference in reported germane cognitive load between English language learners in the high-PERA condition and the English language learners in the low-PERA condition.</td>
<td>Not rejected.</td>
</tr>
<tr>
<td>$H_0^3$</td>
<td>There is no significant difference in reading comprehension scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition.</td>
<td>Not rejected.</td>
</tr>
<tr>
<td><strong>Inquiry Arousal (INQA)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0^4$</td>
<td>There is no significant difference in situational interest scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition.</td>
<td>Not rejected.</td>
</tr>
<tr>
<td>$H_0^5$</td>
<td>There is no significant difference in reported germane cognitive load between English language learners in the high-INQA condition and the English language learners in the low-INQA condition.</td>
<td>Rejected at $p=.046$ confidence level.</td>
</tr>
<tr>
<td>$H_0^6$</td>
<td>There is no significant difference in reading comprehension scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition.</td>
<td>Rejected at $p=.019$ confidence level.</td>
</tr>
<tr>
<td><strong>Interaction between PERA and INQA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_0^7$</td>
<td>There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' situational interest scores.</td>
<td>Not rejected.</td>
</tr>
<tr>
<td>$H_0^8$</td>
<td>There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores.</td>
<td>Rejected at $p=.012$ confidence level.</td>
</tr>
<tr>
<td>$H_0^9$</td>
<td>There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' reading comprehension scores.</td>
<td>Not rejected.</td>
</tr>
</tbody>
</table>

**Dependent Variables Correlations**

A Pearson's product-moment correlation was run in SPSS to assess the relationship between situational interest, cognitive loads, and reading comprehension scores. The analyses showed the relationship to be linear with all variables normally distributed, as assessed by
Shapiro-Wilk's test ($p > .05$), and there were no outliers. There was a strong positive correlation between situational interest and germane cognitive load, $r(155) = 0.55$, $p < .0005$. There was also a moderately positive correlation between intrinsic and extraneous cognitive loads, $r(155) = 0.42$, $p < .0005$. Finally, two small negative correlations were found between situational interest and extraneous cognitive load, $r(155) = -0.21$, $p = .009$, and between extraneous cognitive load and reading comprehension scores, $r(155) = -0.22$, $p = .006$. These results are summarized in Table 12.

Table 12. Pearson's Product Correlations for Dependent Variables.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$M^c$</th>
<th>$SD$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Situational Interest</td>
<td>3.08</td>
<td>0.80</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Intrinsic CL</td>
<td>5.75</td>
<td>2.10</td>
<td>-0.01</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Extraneous CL</td>
<td>4.02</td>
<td>2.29</td>
<td>-0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Germane CL</td>
<td>6.13</td>
<td>2.10</td>
<td>0.55</td>
<td>0.11</td>
<td>-0.07</td>
<td></td>
</tr>
<tr>
<td>5 Reading Comprehension</td>
<td>9.85</td>
<td>3.12</td>
<td>0.06</td>
<td>-0.04</td>
<td>-0.22</td>
<td>0.08</td>
</tr>
</tbody>
</table>

*Note. $^a p < .05$, $^b p < .01$. $^c$ Situational interest score range: 1-5. Cognitive load range: 0-10. Reading comprehension score range: 0-20.*

In addition, effect sizes were calculated between high-PERA (n=78) and low-PERA (n=79) conditions, and between high-INQA (n=78) and low-INQA (n=79) conditions for each of the three dependent variables. Tables 13 and 14 contain a summary of these results.

Table 13. Effect Size for High and Low Perceptual Arousal Conditions.

<table>
<thead>
<tr>
<th></th>
<th>high-PERA $^a$</th>
<th>low-PERA</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>3.08 (SD = 0.81, n =78)</td>
<td>3.10 (SD = 0.79, n =79)</td>
<td>-0.03</td>
<td>-0.34, +0.29</td>
</tr>
<tr>
<td>CLG</td>
<td>5.97 (SD = 1.99, n =78)</td>
<td>6.30 (SD = 2.08, n =79)</td>
<td>-0.16</td>
<td>-0.48, +0.15</td>
</tr>
<tr>
<td>RC</td>
<td>10.18 (SD = 3.10, n =78)</td>
<td>9.53 (SD = 3.06, n =79)</td>
<td>+0.21</td>
<td>-0.10, +0.52</td>
</tr>
</tbody>
</table>

Table 14. Effect Size for High and Low Inquiry Arousal Conditions.

<table>
<thead>
<tr>
<th></th>
<th>high-INQA a</th>
<th>low-INQA</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI</td>
<td>3.18 (SD = 0.81, n = 78)</td>
<td>3.00 (SD = 0.79, n = 79)</td>
<td>+0.21</td>
<td>-0.09, +0.54</td>
</tr>
<tr>
<td>CLG</td>
<td>6.46 (SD = 1.97, n = 78)</td>
<td>5.81 (SD = 2.10, n = 79)</td>
<td>+0.32</td>
<td>+0.00, +0.63</td>
</tr>
<tr>
<td>RC</td>
<td>10.43 (SD = 3.26, n = 78)</td>
<td>9.27 (SD = 2.90, n = 79)</td>
<td>+0.38</td>
<td>+0.06, +0.69</td>
</tr>
</tbody>
</table>


The strong positive correlation between situational interest and germane cognitive load is in line with the model of APA multimedia learning depicted in Figure 1. The moderately positive correlation between intrinsic and extraneous cognitive loads suggests that self-perceived difficulty of this activity was related to its design. The small negative correlation between situational interest and extraneous cognitive load means that as interest increased, the perceived extraneous cognitive load slightly decreased. Likewise, the small negative correlation between extraneous cognitive load and reading comprehension means that an increase in seductive details of the design resulted in a slight decrease in reading comprehension scores, which is also supported by prior research.

Situational Interest

To test null hypotheses H₀₁, H₀₄, and H₀₇, a two-way ANOVA that examined any effects of the perceptual arousal and inquiry arousal on English language learners' situational interest was conducted. Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each cell of the design, and homogeneity of variances was assessed by Levene's test. There were no outliers, but residuals were not normally distributed (p = .021) in the high-PERA, low-INQA condition; however, due to ANOVA’s robustness this violation of normality assumption was considered acceptable (Field, 2013). There was no
evidence of a lack of homogeneity of variances \((p = .981)\). The descriptive statistics are summarized in Table 15.

<table>
<thead>
<tr>
<th>Experimental Condition (^a)</th>
<th>Number of Participants</th>
<th>Mean (^b)</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high- PERA, high-INQA</td>
<td>39</td>
<td>3.20</td>
<td>0.82</td>
<td>-0.19</td>
<td>-0.65</td>
</tr>
<tr>
<td>high- PERA, low-INQA</td>
<td>39</td>
<td>2.95</td>
<td>0.79</td>
<td>-0.63</td>
<td>-0.53</td>
</tr>
<tr>
<td>low- PERA, high- INQA</td>
<td>39</td>
<td>3.15</td>
<td>0.80</td>
<td>0.17</td>
<td>-0.78</td>
</tr>
<tr>
<td>low- PERA, low-INQA</td>
<td>40</td>
<td>3.04</td>
<td>0.78</td>
<td>0.12</td>
<td>-0.63</td>
</tr>
</tbody>
</table>

*Note. \(^a\) PERA: perceptual arousal. INQA: inquiry arousal. \(^b\) Situational interest score range: 1-5.*

The interaction effect between levels of perceptual arousal and inquiry arousal on situational interest was not statistically significant, \(F(1, 153) = 0.284, p = .595, \) partial \(\eta^2 = .002\). Therefore, an analysis of the main effects for perceptual arousal and inquiry arousal levels was performed. The results showed no statistically significant difference in situational interest score between high perceptual arousal and low perceptual arousal, \(F(1, 153) = 0.017, p = .896, \) partial \(\eta^2 < .001, \) or between high inquiry arousal and low inquiry arousal, \(F(1, 153) = 1.905, p = .170, \) partial \(\eta^2 = .012. \) To further check the robustness of the ANOVA results, the procedure was repeated with prior interest as a covariate. The ANCOVA produced similar results. The interaction effect between levels of perceptual arousal and inquiry arousal on situational interest was not statistically significant, \(F(1, 152) = 0.270, p = .604, \) partial \(\eta^2 = .002. \) The analysis of the main effects for perceptual arousal and inquiry arousal levels showed no statistically significant difference in situational interest score between high perceptual arousal and low perceptual arousal, \(F(1, 152) = 0.697, p = .405, \) partial \(\eta^2 = .005, \) or between high inquiry arousal and low inquiry arousal, \(F(1, 152) = 1.373, p = .243, \) partial \(\eta^2 = .009. \) In addition, effect sizes between each of the four conditions were calculated and are shown in Table 16.
Table 16. Effect Size for Situational Interest.

<table>
<thead>
<tr>
<th>condition</th>
<th>high-PERA SD = 0.82, n =39</th>
<th>low-PERA SD = 0.80, n =39</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-INQA</td>
<td>3.20</td>
<td>3.15</td>
<td>+0.06</td>
<td>-0.38, +0.51</td>
</tr>
<tr>
<td>low-INQA</td>
<td>2.95 (SD = 0.79, n =39)</td>
<td>3.04 (SD = 0.78, n =40)</td>
<td>-0.12</td>
<td>-0.56, +0.33</td>
</tr>
</tbody>
</table>

Note.  * PERA: perceptual arousal.  INQA: inquiry arousal.

Based on the above results, null hypothesis H₀₁: “There is no significant difference in situational interest scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition,” was not rejected. In addition, null hypothesis H₀₄: “There is no significant difference in situational interest scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition,” was also not rejected. Finally, null hypothesis H₀₇: “There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' situational interest scores,” was not rejected as well.

Cognitive Loads

To test null hypotheses H₀₂, H₀₅, and H₀₈, a series of three two-way ANOVAs that examined any effects of the perceptual arousal and inquiry arousal on English language learners' cognitive loads was conducted. Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each cell of the design, and homogeneity of variances was assessed by Levene's test. There were no outliers, residuals were normally distributed (p > .05), and there was no evidence of lack of homogeneity of variances (p > .05) for all three cognitive load outcome variables.

Intrinsic Cognitive Load

The descriptive statistics for intrinsic cognitive load are summarized in Table 17.
Table 17. Descriptive Statistics for Intrinsic Cognitive Load.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Number of Participants</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-PERA, high-INQA</td>
<td>39</td>
<td>6.03</td>
<td>2.00</td>
<td>-0.36</td>
<td>0.24</td>
</tr>
<tr>
<td>high-PERA, low-INQA</td>
<td>39</td>
<td>5.93</td>
<td>2.00</td>
<td>-0.43</td>
<td>0.46</td>
</tr>
<tr>
<td>low-ERA, high-INQA</td>
<td>39</td>
<td>5.15</td>
<td>2.19</td>
<td>-0.48</td>
<td>-0.29</td>
</tr>
<tr>
<td>low-ERA, low-INQA</td>
<td>40</td>
<td>5.89</td>
<td>1.98</td>
<td>-0.58</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Note. \(^a\) PERA: perceptual arousal. INQA: inquiry arousal. \(^b\) Intrinsic cognitive load score range: 0-10.

The interaction effect between levels of perceptual arousal and inquiry arousal on intrinsic cognitive load was not statistically significant, \(F(1, 153) = 1.691, p = .195\), partial \(\eta^2 = .011\). Therefore, an analysis of the main effects for perceptual arousal and inquiry arousal levels was performed. The results showed no statistically significant difference in intrinsic cognitive load score between high perceptual arousal and low perceptual arousal, \(F(1, 153) = 2.025, p = .157\), partial \(\eta^2 = .013\), or between high inquiry arousal and low inquiry arousal, \(F(1, 153) = .973, p = .326\), partial \(\eta^2 = .006\).

**Extraneous Cognitive Load**

The descriptive statistics for extraneous cognitive load are summarized in Table 18.

Table 18. Descriptive Statistics for Extraneous Cognitive Load.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Number of Participants</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-ERA, high-INQA</td>
<td>39</td>
<td>4.15</td>
<td>2.47</td>
<td>0.36</td>
<td>-0.46</td>
</tr>
<tr>
<td>high-ERA, low-INQA</td>
<td>39</td>
<td>3.46</td>
<td>1.96</td>
<td>0.08</td>
<td>-0.09</td>
</tr>
<tr>
<td>low-ERA, high-INQA</td>
<td>39</td>
<td>3.59</td>
<td>2.38</td>
<td>0.50</td>
<td>-0.05</td>
</tr>
<tr>
<td>low-ERA, low-INQA</td>
<td>40</td>
<td>4.22</td>
<td>2.32</td>
<td>0.44</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note. \(^a\) PERA: perceptual arousal. INQA: inquiry arousal. \(^b\) Extraneous cognitive load score range: 0-10.

The interaction effect between levels of perceptual arousal and inquiry arousal on extraneous cognitive load was not statistically significant, \(F(1, 153) = 0.879, p = .350\), partial \(\eta^2 = .006\). Therefore, an analysis of the main effects for perceptual arousal and inquiry arousal levels was performed. The results showed no statistically significant difference in extraneous
cognitive load score between high perceptual arousal and low perceptual arousal, \( F(1, 153) = 0.363, p = .548, \) partial \( \eta^2 = .002, \) or between high inquiry arousal and low inquiry arousal, \( F(1, 153) = .600, p = .440, \) partial \( \eta^2 = .004. \)

**Germane Cognitive Load**

The descriptive statistics for germane cognitive load are summarized in Table 19.

### Table 19. Descriptive Statistics for Germane Cognitive Load.

<table>
<thead>
<tr>
<th>Experimental Condition a</th>
<th>Number of Participants</th>
<th>Mean b</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-PERA, high-INQA</td>
<td>39</td>
<td>6.71</td>
<td>1.75</td>
<td>-0.13</td>
<td>-0.21</td>
</tr>
<tr>
<td>high-PERA, low-INQA</td>
<td>39</td>
<td>5.22</td>
<td>2.23</td>
<td>-0.58</td>
<td>-0.52</td>
</tr>
<tr>
<td>low-PERA, high-INQA</td>
<td>39</td>
<td>6.21</td>
<td>2.18</td>
<td>-0.14</td>
<td>-0.84</td>
</tr>
<tr>
<td>low-PERA, low-INQA</td>
<td>40</td>
<td>6.39</td>
<td>1.97</td>
<td>-0.46</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*Note.* a PERA: perceptual arousal. INQA: inquiry arousal. b Germane cognitive load score range: 0-10.

There was a statistically significant, disordinal interaction between perceptual and inquiry arousal levels on germane cognitive load, \( F(1, 153) = 6.511, p = .012, \) partial \( \eta^2 = .041, \) as shown in Figure 11. However, an analysis of simple main effects for perceptual and inquiry arousal levels was still performed at the \( p < .05 \) level. There was no statistically significant difference in mean "germane cognitive load" scores between high perceptual arousal and low perceptual arousal, \( F(1, 153) = 1.076, p = .301, \) partial \( \eta^2 = .007; \) however, there was statistically significant difference in mean "germane cognitive load" scores between high inquiry arousal and low inquiry arousal, \( F(1, 153) = 4.047, p = .012, \) partial \( \eta^2 = .041. \) To further check the robustness of the ANOVA results, the procedure was repeated with prior knowledge as a covariate. The ANCOVA produced similar results. The interaction effect between levels of perceptual arousal and inquiry arousal on germane cognitive load was also statistically significant, \( F(1, 152) = 6.204, p = .014, \) partial \( \eta^2 = .039. \) The analysis of the simple effects for perceptual arousal and inquiry arousal levels showed no statistically significant difference in germane cognitive load
score between high perceptual arousal and low perceptual arousal, \( F(1, 152) = 1.004, p = .318, \) partial \( \eta^2 = .007 \), but analysis did show statistically significant difference between high inquiry arousal and low inquiry arousal, \( F(1, 152) = 3.945, p = .049, \) partial \( \eta^2 = .025 \). In addition, effect sizes between each of the four conditions were calculated and are shown in Table 20.

Table 20. Effect Size for Germane Cognitive Load.

<table>
<thead>
<tr>
<th></th>
<th>high-PERA</th>
<th>low-PERA</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-INQA</td>
<td>6.71 (SD = 1.75, n =39)</td>
<td>6.21 (SD = 2.18, n =39)</td>
<td>+0.25</td>
<td>-0.19, +0.70</td>
</tr>
<tr>
<td>low-INQA</td>
<td>5.22 (SD = 2.23, n =39)</td>
<td>6.39 (SD = 1.97, n =40)</td>
<td>-0.56 (^b)</td>
<td>-1.01, -0.11</td>
</tr>
</tbody>
</table>

Note. \(^a\) PERA: perceptual arousal. INQA: inquiry arousal. \(^b\) Cohen's medium effect size.

Figure 11. Interaction Effect for Germane Cognitive Load.
For the high-PERA, high-INQA condition the interaction effect was strong and positive 0.74, 95% CI [0.28 to 1.20]. For the low-PERA, low-INQA condition the interaction effect was weak and negative -0.09, 95% CI [-0.53 to 0.35]—as calculated using the Practical Meta-Analysis Effect Size Calculator (Wilson, 2017). In other words, in the low perceptual arousal condition, low inquiry design had slightly higher impact on germane cognitive load than the high inquiry design. However, in the high perceptual arousal condition, high inquiry design had a much higher impact on germane cognitive load than low inquiry design.

Based on the above results, null hypothesis H02: “There is no significant difference in reported germane cognitive load between English language learners in the high-PERA condition and the English language learners in the low-PERA condition,” was not rejected. However, null hypothesis H05: “There is no significant difference in reported germane cognitive load between English language learners in the high-INQA condition and the English language learners in the low-INQA condition,” was rejected at .05 confidence level. Finally, null hypothesis 8 H08: “There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores,” was rejected at .05 confidence level.

**Reading Comprehension**

To test null hypotheses H03, H06, and H09, a two-way ANOVA that examined any effects of the perceptual arousal and inquiry arousal on English language learners' reading comprehension was conducted. Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot, normality was assessed using Shapiro-Wilk's normality test for each cell of the design, and homogeneity of variances was assessed by Levene's test. There were no outliers, residuals were normally
distributed ($p > .05$), and there was no evidence of a lack of homogeneity of variances ($p = .665$). The descriptive statistics are summarized in Table 21.

Table 21. Descriptive Statistics for Reading Comprehension.

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Number of Participants</th>
<th>Mean $^b$</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-PERA, high-INQA</td>
<td>39</td>
<td>10.72</td>
<td>3.20</td>
<td>0.10</td>
<td>-0.69</td>
</tr>
<tr>
<td>high-PERA, low-INQA</td>
<td>39</td>
<td>9.64</td>
<td>3.00</td>
<td>-0.27</td>
<td>-0.38</td>
</tr>
<tr>
<td>low-PERA, high-INQA</td>
<td>39</td>
<td>10.15</td>
<td>3.32</td>
<td>0.19</td>
<td>-0.66</td>
</tr>
<tr>
<td>low-PERA, low-INQA</td>
<td>40</td>
<td>8.90</td>
<td>2.79</td>
<td>-0.17</td>
<td>-0.86</td>
</tr>
</tbody>
</table>

Note. $^a$ PERA: perceptual arousal. INQA: inquiry arousal. $^b$ Reading comprehension score range: 0-20.

The interaction effect between levels of perceptual arousal and inquiry arousal on reading comprehension was not statistically significant, $F(1, 153) = 0.032, p = .857$, partial $\eta^2 < .001$. Therefore, an analysis of the main effects for perceptual arousal and inquiry arousal levels was performed. The results showed no statistically significant difference in situational interest score between high perceptual arousal and low perceptual arousal, $F(1, 153) = 1.762, p = .186$, partial $\eta^2 = .011$. However, a main effect between high inquiry arousal and low inquiry arousal was found to be statistically significant, $F(1, 153) = 5.618, p = .019$, partial $\eta^2 = .035$. All pairwise comparisons were run for each simple main effect with reported 95% confidence intervals. The marginal means for "Reading Comprehension" score were 10.18 ($SE=0.35$) for high perception arousal and 9.53 ($SE=0.35$) for low perception arousal, a statistically insignificant mean difference of 0.65, 95% CI [-0.32, 1.62], $p = .186$. The marginal means for "Reading Comprehension" score were 10.44 ($SE=0.35$) for high inquiry arousal and 9.27 ($SE=0.35$) for low inquiry arousal, a statistically significant mean difference of 1.17, 95% CI [0.19, 2.14], $p = .019$. In addition, effect sizes between each of the four conditions were calculated and are shown in Table 22.
Table 22. Effect Size for Reading Comprehension.

<table>
<thead>
<tr>
<th>Condition</th>
<th>high-PERA  *</th>
<th>low-PERA</th>
<th>Effect Size</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-INQA</td>
<td>10.72 (SD = 3.20, n =39)</td>
<td>10.15 (SD = 3.32, n =39)</td>
<td>+0.17</td>
<td>-0.27, +0.62</td>
</tr>
<tr>
<td>low-INQA</td>
<td>9.64 (SD = 3.00, n =39)</td>
<td>8.90 (SD = 2.80, n =40)</td>
<td>-0.26 b</td>
<td>-0.19, +0.70</td>
</tr>
</tbody>
</table>

Note. * PERA: perceptual arousal. INQA: inquiry arousal. b Cohen's small effect size.

Based on the above results, null hypothesis H₀3: “There is no significant difference in reading comprehension scores between English language learners in the high-PERA condition and English language learners in the low-PERA condition,” was not rejected. However, null hypothesis H₀6: “There is no significant difference in reading comprehension scores between English language learners in the high-INQA condition and English language learners in the low-INQA condition,” was rejected at .019 confidence level. Finally, null hypothesis H₀9: “There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' reading comprehension scores,” was not rejected.

Conclusions

Based on the empirical evidence presented in this chapter, the null hypotheses H₀1, H₀4, and H₀7 were not rejected, meaning that there was no statistically significant effect of perceptual and/or inquiry condition(s) on situational interest. Similarly, null hypothesis H₀2 was not rejected, but null hypotheses H₀5: “There is no significant difference in reported germane cognitive load between English language learners in the high-INQA condition and the English language learners in the low-INQA condition,” and H₀8: “There is no significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores,” were rejected at \( p = .046 \) and \( p = .012 \), respectively, suggesting that inquiry arousal and interaction between inquiry and perceptual...
arousal have effects on the germane cognitive loads. Finally, the null hypotheses $H_03$ and $H_09$ were not rejected, but null hypothesis $H_06$: “There is no significant difference in reading comprehension scores of English language learners in the high-INQA condition with those of English language learners in the low-INQA condition,” was rejected at $p=.019$ confidence level implying that high inquiry arousal has an effect on reading comprehension. The next chapter further discusses these findings, their implications, possible future research directions, and presents final conclusions.
CHAPTER FIVE: DISCUSSION

Although many students in industrialized nations are proficient readers, they often struggle with reading comprehension, partially due to low interest in reading (Renninger & Hidi, 2011; Schraw & Lehman, 2001). The increasing popularity of technology-based multimedia devices in Western cultures is recognized as an important factor in shaping student identities in the 21st century, and also raises many questions about the potential role of electronic texts in reading and learning. Since interest and attention are linked (Ainley, Hidi, & Berndorff, 2002; Heidi, Renninger, & Krapp, 2004; McDaniel, Waddill, Finstad, & Bourg, 2000), educational research is starting to look at how new multimedia technologies can make existing texts more interesting by making them more attractive to readers. Previous studies suggested ways to combine textual and multimedia materials to trigger and maintain students’ attention without distracting them from the learning content (Park, 2015; Smith et al., 2013). Animated pedagogical agents (APAs) based on multimedia design principles are known to stimulate attention in text and increase germane cognitive load through generative processing in multimedia learning without increasing extraneous cognitive load (Mayer, 2014; Park, 2015). However, it is not clear how different APA arousal components contribute to the overall effectiveness of instructional designs that use them. This research examined how four different APA designs based on two types of arousal, perceptual arousal and inquiry arousal as defined in Keller’s ARCS model of motivational design (Keller, 2009; Nakaima, 2014), impacted English language learners’ situational interest, germane cognitive load, and reading comprehension in online readings task. Three research questions were explored—RQ1: “What is the effect of
perceptual arousal presented by a pedagogical agent on English language learners’ situational interest, cognitive loads, and reading comprehension in online English reading tasks?”; RQ2: “What is the effect of inquiry arousal presented by a pedagogical agent on English language learners’ situational interest, cognitive loads, and reading comprehension in online English reading tasks?”; RQ3: “Are there any interaction effects between perceptual arousal and inquiry arousal presented by a pedagogical agent on English language learners’ situational interest, cognitive loads, and reading comprehension in online English reading tasks?” Each research question was broken into three hypotheses—with foci on situational interest, germane cognitive load, and reading comprehension—and corresponding null hypotheses were tested using statistical methods covered in the previous chapter. The results are summarized in Table 23.

Table 23. Summary of Findings.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Interaction Effect PERA * INQA</th>
<th>Main Effect of PERA</th>
<th>Main effect of INQA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situational Interest</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Intrinsic Cognitive Load</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Extraneous Cognitive Load</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Germane Cognitive Load</td>
<td>( p = 0.012 )</td>
<td>-</td>
<td>( p = 0.046 )</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>-</td>
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*Note.* \( \text{PERA}: \) perceptual arousal. \( \text{INQA}: \) inquiry arousal. \( p \): calculated p-value. \( d \) Intrinsic and extraneous loads did not have a corresponding null hypothesis.

The findings indicate the main effects of inquiry arousal on students' germane cognitive load \( (p = 0.046) \) and on reading comprehension \( (p = 0.019) \). Also an interaction effect was found between the inquiry arousal and the perceptual arousal on germane cognitive load \( (p = 0.012) \).
Discussion

Situational Interest

This research did not find sufficient evidence to reject the null hypotheses $H_01$, $H_04$, and $H_07$. Therefore, hypothesis $H1$: “English language learners in the high-PERA condition will show significantly higher situational interest scores than English language learners in the low-PERA condition,” was rejected. Also, hypothesis $H4$: “English language learners in the high-INQA condition will show significantly higher situational interest scores than English language learners in the low-INQA condition,” was rejected. Finally, hypothesis $H7$: “There is a significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' situational interest scores,” was also rejected. In other words, this study did not discover any effect of perceptual and/or inquiry arousal presented by a pedagogical agent on English language learners' situational interest in online English reading tasks. Prior research has shown that mere presence of images does not significantly affect perceived situational interest (Park, 2015). This aligns with the current findings that visual stimulation, as part of a perceptual arousal condition embedded in animated pedagogical agents (APAs), does not necessarily improve perceived situational interest. Based on dual-channel and limited capacity assumptions of CTML, it is possible that the visual input channel was fully utilized by textual materials, leaving little room for any perceptual arousal triggers introduced by the APA (Mayer, 2009). Further support for this idea is shown by the outcomes of the manipulation check (MC), mean=0.56, SD=0.30 which correlates with neutral SI scores. These results indicate that almost half of the MC questions were answered incorrectly, suggesting that students did not pay as much attention to the APA as expected. It is possible that some MC items were misunderstood or misleading to the sample population, but it is also possible that
because of a relatively high intrinsic cognitive load (mean=5.75, SD=2.06), subjects were simply more focused on the text and not so much on the visual components of the APA, and the premise of the incongruity theory was never realized (Kagan, 1972). At the same time, the APA high inquiry triggers may not have been sufficient to visibly stimulate situational interest based on the trigger-maintenance model of the knowledge depravation hypothesis. In other words, the high-INQA condition did not deliver enough "thirst for knowledge" to be "quenched" through "epistemic curiosity" (Rotgans & Schmidt, 2014).

Situational interest is defined as “focused attention and an affective reaction that is triggered in the moment by environmental stimuli, which may or may not last over time” (Hidi & Renninger, 2006), and it was operationalized in this study using a self-reported, six-item measure. It is possible that the APA did not trigger situational interest (SI) because the SI level might have already been set by the novelty of the interaction or the introduction itself. This "residual" SI possibly diminished any potential APA impact, and the short duration (approximately 30 minutes) of this reading activity might not have been enough to accurately capture any effects of different APA designs. Finally, the SI instrument itself may not have been adequate to capture the situational interest imparted by the APA. It is possible that the contribution of the text was stronger than that of the APA designs, and the CL measure was capturing the overall effect of the activity on the situational interest. There was a strong positive correlation, $r(155) = 0.552, p < .0005$ between situational interest and germane cognitive load, which supports this view.
Cognitive Loads

With the exception of germane cognitive load, this research study did not find any evidence that perceptual and/or inquiry arousal conditions have any effect on intrinsic and extraneous cognitive loads. According to Kalyuga (2010) and Plass et al. (2010), intrinsic cognitive load is derived from inherent difficulty of the material, and extraneous cognitive load comes from unnecessary or improperly implemented elements of instruction. The lack of evidence that extraneous cognitive load was significantly impacted by high and/or low perceptual and inquiry conditions suggests that animated pedagogical agents used in this study were properly designed and implemented.

This research did not find sufficient evidence to reject the null hypothesis $H_0^2$; therefore, hypothesis $H_2$: “English language learners in the high-PERA condition will report significantly higher germane cognitive load scores than English language learners in the low-PERA condition” was rejected. However, null hypotheses $H_0^5$ and $H_0^8$ were rejected. Therefore, alternative hypothesis $H_5$: “English language learners in the high-INQA condition will report significantly higher germane cognitive load scores than English language learners in the low-INQA condition” was accepted. Also, alternative hypothesis $H_8$: “There is a significant interaction effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' germane cognitive load scores” was accepted.

ANOVA interactions can be interpreted by looking at how one of the independent variables (IVs) affects the dependent variable for the levels of the other independent variable. In this case the simple effects are different for the levels of the other IV, indicating an interaction effect depicted in Figure 11. First, this study looked at how perceptual arousal (PERA) affects germane cognitive load in the presence of high and low inquiry arousal (INQA). In case of the
low-INQA, the effect is negative (-0.56) and moderate. In case of the high-INQA, the effect is positive (+0.25) and small. What this means that when low inquiry arousal is present, the effect of high vs. low perceptual arousal on germane cognitive load is medium and negative, which is bad. On the other hand, when high inquiry arousal is present, the effect of high vs. low perceptual arousal on germane cognitive load is small but positive, which is somewhat good.

Second, this study examined how inquiry arousal (INQA) affects germane cognitive load in the presence of high and low perceptual arousal (PERA). In case of the low-PERA, the effect is negative (-0.09) and very small. In case of the high-PERA, the effect is positive (+0.74) and moderate. What this means that when low perceptual arousal is present the effect of high vs. low inquiry arousal on germane cognitive load is small and negative, which is bad. On the other hand, when high perceptual arousal is present the effect of high vs. low inquiry arousal on germane cognitive load is large and positive, which is really good. When inquiry arousal is low, the high perceptual arousal has negative impact on germane cognitive load, and vice versa, when perceptual arousal is low, the high inquiry arousal has negative impact on generative processing. This means that in the presence of high perceptual arousal the high inquiry conditions built into animated pedagogical agents likely take advantage of existing generative underutilization and, according to affective mediation assumptions of CATLM, result in higher germane cognitive loads. Since high inquiry conditions use the audio channel, they do not seem to interfere with the visual text inputs as predicted by the dual-channel and limited capacity assumptions of CTML (Mayer, 2014). In addition, combined high perceptual and high inquiry conditions built into animated pedagogical agents appear to result in much higher germane cognitive load, while low perceptual and low inquiry conditions built into APA result in a slightly higher (but still significant) germane cognitive load. These findings are in line with Mayer's personalization and
voice principles (2009). Animated pedagogical agents designed around conversational style with friendly human voice are more likely to produce improved learning outcomes, or in this case, increased generative processing. Mixed conditions did not produce significant positive differences in germane cognitive loads, suggesting that conflicting levels of arousal condition possibly introduce incongruities, which, in turn, cancel out any perceptual or inquiry arousal effects.

According to the embodiment principle, in order to foster generative processing, animated pedagogical agent designs should include human-like gesturing, movement, eye contact, and facial expressions (Mayer, 2014a). In other words, spoken messages and visuals should align with one another and should not introduce conflicting or “unnatural” inputs. These findings are also supported by the active processing assumption of cognitive load theory (CTML, Mayer 2009) and the affective mediation assumption of cognitive-affective theory of multimedia learning (CATLM; Moreno, 2005; Moreno & Mayer, 2007). According to Mayer, emotions play an important role in learning, and "seductive details,” that is, elements of the design that distract students from the learning objectives, could undermine the effectiveness of multimedia materials (Mayer, 2009). In this particular case, the mixed perceptual and inquiry arousal conditions could be perceived as distracting to students. This means that designs of pedagogical agents should ensure that both high perceptual and high inquiry arousal conditions are present.

**Reading Comprehension**

This research did not find sufficient evidence to reject the null hypotheses $H_03$ and $H_09$. Therefore, alternative hypothesis H3: “English language learners in the high-PERA condition will show significantly higher reading comprehension scores than English language learners in the low-PERA condition” was rejected. Also, hypothesis H9: “There is a significant interaction
effect between PERA and INQA conditions presented by a pedagogical agent on English language learners' reading comprehension scores” was rejected. However, since null hypothesis $H_0$ was rejected, the alternative hypothesis $H_6$: “English language learners in the high-INQA condition will show significantly higher reading comprehension scores than English language learners in the low-INQA condition” was accepted.

This outcome should not be surprising since “pre-reading” questions, such as the ones delivered by high inquiry conditions in this study, are known to simulate curiosity and lead to better learning outcomes (Ajideh, 2003; Chastain, 1988). The CTML active processing assumption that "meaningful learning occurs when the learners spend conscious effort in cognitive processing,” also supports this finding (Mayer, 2009). The affective mediation assumption of CATLM suggests that motivational factors can affect learning by increasing the cognitive engagement. The role of an APA is to take advantage of any generative underutilization and to optimize the germane cognitive activities (Mayer, 2014). The high inquiry arousal condition contained relevant questions, which lead to higher germane cognitive load and resulted in improved reading comprehension. The high perceptual arousal by itself did not show any significant effect on reading comprehension. The perceptual triggers used in the APA design might have been perceived by users as distractors even though high PERA conditions did not result in higher extraneous cognitive loads. The CTML coherence principle, which states that people learn more deeply from a multimedia message when extraneous material is excluded (Mayer, 2009), provides support for this view.
Implications

**Theoretical implications**

Previous studies support benefits of instructional designs based on the cognitive theory of multimedia learning (CTML) and cognitive-affective theory of learning with multimedia (CATLM) design principles which can increase learner’s motivation and improve learning outcomes by increasing generative processing (Heidig et al., 2014; Mayer & Estrella, 2014; Park, 2015; Plass et al., 2012; Um et al., 2011). This study has shown that in the presence of high perceptual arousal, the high inquiry arousal delivered by animated pedagogical agents (APA) in online reading activities results in an increase in germane cognitive load, as well as improved reading comprehension, which can be viewed as further validation of prior research and support for learning with APAs. However, the results of this study also indicate that dual-channel, limited capacity assumptions play an important role in multimedia reading activities involving animated pedagogical agents. This study did not find any main effects of perceptual arousal on situational interest, cognitive loads, or reading comprehension scores, suggesting that perceptual arousals built into APA designs may not always be the best fit for online reading activities designed to foster affective mediation.

In addition, the present research has revealed that perceptual arousal and inquiry arousal are only good when both are used at the same level, that is, either high or low (but especially high). The effect of an APA on germane cognitive load appears to be negative and limited when levels of arousal triggers are mixed. This could be an important finding but it requires additional research validation. Overall, this study had shown that perceptual and/or inquiry arousals triggered by animated pedagogical agents embedded in online reading activities can produce complex outcomes which should be investigated by further research.
Practical implications

Online reading activities which incorporate animated pedagogical agents to improve reading comprehension should include high inquiry arousal triggers, such as content relevant questions. In addition, instructional designers should refrain from mixing high and low perceptual and inquiry arousals in their designs of animated pedagogical agents and should attempt to use both high perceptual and high inquiry arousal triggers.

Suggestions for Future Research

The sample population for this study consisted mostly of young male adults over 18 with predominantly Arabic and Chinese ethnicity. Some previous studies have shown that students could shift their attention on the basis of personal and gender-related interests (Renninger & Wozniak, 1985). This should be considered when making any type of cross-cultural or gender based generalizability claims. General interests may also have a low degree of variability within each developmental age group. In other words, a more diverse sample of students may be required to establish the external validity of the results when projecting to a wider population. Additionally, both texts selected for this experiment were dealing with a topic of war and can be considered of "sensitive nature". Using different topics could also extend generalizability of future studies.

High intrinsic cognitive loads can leave very little room for generative underutilization, which could explain why the manipulation check returned low scores. Some anecdotal evidence based on in-class observations suggests that participants of this study found the text material difficult and requiring extensive focus, explaining their low scores on the manipulation check. Repeating this research with more advanced English learners could yield some additional insights.
The low reliability (α=.572) of the reading comprehension (RC) measure used in this study could be slightly improved by removing or modifying some of the items, for example, #7 (Williamsburg is mentioned as a meeting place of allied forced), #8 (The surrender of Cornwallis can be viewed as a diplomatic settlement), or #20 (The author implies that Andersonville Prison was surrounded by a high wall). However, it is possible that low instrument reliability was caused primarily by the high intrinsic cognitive loads. It might be interesting to further examine what the reliability of the RC measure would look like in populations with higher English comprehension levels.

Finally, qualitative methods should be included in future research to look into some of the possible explanations why this study did not find any effect of perceptual and inquiry arousals on situational interest despite a strong correlation between situational interest and germane cognitive load.

Conclusions

The fact that students learn better when they are emotionally aroused by the material has been known for quite some time (Kintsch, 1980; Weiner, 1990). Although interest is considered one of the most important factors in learning from textual materials, even most stimulating animated pedagogical agents are not a substitute for well-trained and dedicated teachers. This research study does not make any suggestions that interesting multimedia can replace teachers or change the way effective education proceeds in a classroom. Rather, it attempts to illustrate how animated pedagogical agents can improve generative cognitive processing and learning outcomes by creating self-paced and engaging reading environments which can then be explored by educators. The purpose of this study was to examine if pedagogical agents with arousal conditions bring any additional affordances to reading and learning from textual materials.
Overall, the high inquiry arousal built into animated pedagogical agents appears to be beneficial in improving reading comprehension. In addition, combined high perceptual arousal and high inquiry arousal conditions delivered via animated pedagogical agents significantly increase germane cognitive load, which is known to benefit motivation and learning outcomes (Mayer, 2014; Park, 2015). However, mixed designs of animated pedagogical agents which include high perception and low inquiry, or low perception and high inquiry triggers appear to have negative effect on germane cognitive load and should not be used in reading tasks intended to improve generative processing.

**Personal Statement**

The impetus for the research inquiry into effects of pedagogical agents on situational interest came from the ontological belief that although reality is partially constructed by individuals, the result may vary significantly depending on personal perceptions. My ontological perspective is rooted in critical theory, but it is also framed by pragmatic and post-positivist views of education. The epistemological framework which guided this study is derived from constructive developmentalism and is informed by CLT, CTML, CATLM, and ARCS models of motivational design. Although this was not a mixed-methods study, my methodological perspective embraces both the qualitative and quantitative methods as part of the same inquiry—based on the experimental design and qualitative observations. I strongly believe in a core methodology based on post-positivist principles of empirical inquiry but wrapped in pragmatic, constructivist methods informed by a number of critical theories. This leads to the axiology of this research, which is based on a critical perspective and my desire to aid in research of multimedia texts and instructional methods to promote development of reading comprehension literacy skills among disinterested or disfranchised students. Text literacy skills are necessary
for academic and professional success, but their application is also critical to the development of affinity for reflective thought, which shapes moral integrity and citizenship. In order to continue the tradition of quality intellectual discourse that exposes the many threats to liberal education, economic security, social justice, and democracy, our educational system must continue to produce large numbers of students who are not only knowledgeable about their chosen discipline, but also among other things, have a highly developed reading comprehension skills and a demonstrated propensity for reflectivity. Technological advances are turning new generations away from recreational and other forms of reading, impeding reading comprehension skills and negatively affecting students' personal development. Improved understanding of animated pedagogical agent designs in multimedia learning and their effects on reading motivation is a small but important step in a much larger research program.
REFERENCES


Appendix A: Text Interest Survey and Results

1. **Small but Mighty:** Wood decay is caused by small plants called fungi. These plants cannot live on wood that has a moisture content of less than about 30 percent. The wood in most well-built homes is safe because the moisture content is rarely above 15 percent…

2. **Busy Little Carpenters:** Most people think of termites when they think of insects that live in wood. But there are other kinds of wood-nesting insects. Unlike termites, carpenter ants and carpenter bees do not eat wood…

3. **Garden Flowers:** Farmers and gardeners in North America raise about 30,000 species of flowers. Many kinds of flowering plants are grown for food. But most are garden flowers, grown for decoration…

4. **Liquids, Granules, and Powders:** Scientists tell us that there are from three to ten million known species of insects in the world. Thousands more are identified every year. Many of the known insects feed on living plants…

5. **Agony at Andersonville:** Andersonville was a prison for enlisted Union soldiers during the United States Civil War. Officers, after the first few months, were confined at Macon. The first group of prisoners arrived at the camp on February 27, 1864…
6. The Surrender at Yorktown: The surrender of the British army at Yorktown on October 19, 1781, marked the close of the American Revolution. It ended almost seven years of war…

7. The King of Ragtime: Scott Joplin, born into a musical family in Texarkana, Texas in 1868, was destined to become one of America’s greatest black artists. At the age of 14, he had mastered the piano and was determined to become a professional musician…

8. A Green Thumb: Container gardening is especially adapted to contemporary living. Houseplants are as compatible with the bold, simple lines of contemporary architecture as with the intricate lines of many older homes…

9. The History of Stained Glass: All colored glass is “stained” by the integration of appropriate metal oxides or other chemical compounds in the glass manufacture. However, the term traditionally refers to an art form – the creation of stained glass window…

10. Highways and Byways: Beautiful highways are safer because they provide restful and scenic views that reduce the monotony of driving. A beautiful and safety-enhancing feature of modern highways is a wide, landscaped median…

11. A Place for Everything: Most people think their homes are safe, but frequently they are not. Statistics show a large proportion of accidents occur there…
12. **Hills and Curves:** Highway engineers have three objectives in planning and constructing today’s heavily traveled transportation arteries. The objectives are greater safety, reduced maintenance costs, and general roadside attractiveness…

### Table 8. Interest scores (n=26).

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</tbody>
</table>
Appendix B: Selected Texts with Questions

The Surrender at Yorktown (Timed Readings, Book Eight, p.99)

The surrender of the British army at Yorktown on October 19, 1781, marked the close of the American Revolution. It ended almost seven years of war. While the treaty of peace was not signed until later, the victory at Yorktown was the decisive event in the struggle to make the United States an independent nation.

In 1781, the British had practically abandoned efforts to re-conquer the northern states. But they still had hopes of regaining the South. That spring, Lieutenant General Earl Cornwallis marched into Virginia from North Carolina. He believed that if Virginia could be subdued, the states to the south would readily return to British allegiance.

The Marquis de Lafayette, operating in Virginia with a small American force, was unable to meet Cornwallis in open battle. The British army marched up and down the state almost at will, but failed to break the resistance of the people. Cornwallis was directed to fortify a naval base in lower Chesapeake.

Cornwallis chose Yorktown for the base and transferred his army there early in August. He began fortifying the town and Gloucester Point across the river. Meanwhile, a French fleet under Count de Grasse was moving up for combined operations with the allied French and American armies. Count de Grasse blocked the mouth of Chesapeake Bay, cutting off Cornwallis from help by sea. Washington then moved his forces toward Virginia to attack by land. These forces included part of the main American army operating on the Hudson and the French army under Count de Rochambeau.

While de Grasse maintained a blockade by sea, the combined armies gathered at Williamsburg. On September 28th, they marched down the peninsula and laid siege to Yorktown, with its British garrison of 7,500. Cornwallis almost immediately abandoned his outer line and retired within the town. During the night of October 6, the allied armies opened entrenchments and a few days later began a heavy bombardment of the British position. Their fire soon subdued Cornwallis, and the allies were able to close in at shorter range. Two outlying British forts were stormed. The British army was then in an extremely desperate position. Cornwallis made an attempt to escape by way of Gloucester, but his boats were scattered by a storm. On the morning of October 17, he sent out a flag of truce and asked Washington for a discussion of terms of surrender.
1. The British army surrendered at Yorktown in the early
   a. 1770s
   b. **1780s**
   c. 1790s
2. The American Revolution lasted almost
   a. **seven years**
   b. nine years
   c. eleven years
3. Cornwallis felt that the most important state to conquer in the South was
   a. Kentucky
   b. Georgia
   c. **Virginia**
4. American forces were aided by the
   a. Germans
   b. **French**
   c. Canadians
5. Yorktown's British garrison comprised
   a. 2,500 men
   b. 5,500 men
   c. **7,500 men**
6. The author implies that Count de Grasse was
   a. a naval commander
   b. a personal friend of Washington
   c. an expert in land strategy
7. Williamsburg is mentioned as
   a. the city of a great American defeat
   b. British base of operations
   c. a **meeting place of allied forces**
8. The surrender of Cornwallis can be viewed as a
   a. bloody encounter
   b. **diplomatic settlement**
   c. fateful accident
9. The author states that Cornwallis was
   a. defeated because of poor planning
   b. unable to escape because of bad weather
   c. an expert naval officer
10. We can conclude that the American victory
    a. **ended the British occupation of America**
    b. divided the country into halves
    c. was the only battle lost by the British
Agony at Andersonville (Timed Readings, Book Eight, p.53)

Andersonville was a prison for enlisted Union soldiers during the United States Civil War. Officers, after the first few months, were confined at Macon. The first group of prisoners arrived at the camp on February 27, 1864, before the prison was completed. In the months that followed, others arrived at the rate of about 400 per day.

Overcrowding was a serious problem. By late June some 26,000 soldiers were confined in a stockade built to accommodate 10,000. By the end of July, the constant arrival of new prisoners raised the total number of soldiers being held in the prison to 31,678.

Next to overcrowding, the absence of adequate housing caused the greatest suffering. Lacking the necessary tools, the Confederates could not provide shelter for their captives. The prisoners were accordingly required to provide their own shelter. Early arrivals gathered up the lumber, logs, and branches remaining from the constructions of the stockade and built rude huts. The wood supply was soon exhausted. The more resourceful Federals improvised tents, or "shebangs," from odd bits of clothing. These proved inadequate, especially during rains. Risking suffocation from cave-ins, many prisoners dug holes in the ground for protection. When it rained, these holes quickly filled with water. Hundreds of Union soldiers were without shelter of any kind against rain, sun, heat and cold.

The daily food ration, the cause of severe dietary deficiencies, consisted of one-quarter pound of meal and either one-third pound of bacon or one pound of beef. Occasionally, peas, rice, vinegar, and molasses were provided. Food was usually issued uncooked. Prison officials had intended to cook the rations before distributing them, but the prisoners arrived before facilities had been completed. By the time a cookhouse and a bakehouse were finished in the summer of 1864, they were wholly inadequate.

The overcrowding, the inadequate shelters, the coarse, meager rations, and the poor sanitary conditions resulted in widespread disease and a high mortality rate. Altogether more than 45,000 Union soldiers had been confined in Andersonville. More than 12,000 were buried in the Andersonville cemetery. Most of the deaths were caused by diarrhea, dysentery, gangrene, and scurvy, diseases that the Confederate surgeons could not arrest because they lacked proper facilities, personnel, medical supplies, and medicines. During the prison's thirteen-month existence, more than 900 prisoners died each month. The greatest death toll on any single day occurred on August 23, 1864, when 97 prisoners died.
1. Prisoners arrived at Andersonville at the rate of four hundred per
   a. day
   b. week
   c. month
2. At one time, Andersonville contained more than
   a. 25,000 men
   b. 50,000 men
   c. 75,000 men
3. "Shebangs" were
   a. guards
   b. tents
   c. rations
4. Prisoners ate their food uncooked because
   a. guards were inhuman
   b. cooking was unnecessary
   c. facilities were inadequate
5. Andersonville was used as a prison for about
   a. one year
   b. two years
   c. three years
6. Andersonville was built to accommodate
   a. twice the number of prisoners actually detained there
   b. the exact number who served their sentences there
   c. less than one-half the number of prisoners who were held there
7. The daily food rations for each prisoner consisted mostly of
   a. meat
   b. fruit
   c. vegetables
8. In this article, the author fails to mention the
   a. location of Andersonville
   b. number of deaths occurring in Andersonville
   c. types of shelters constructed at Andersonville
9. Confederate surgeons could not help many prisoners because the surgeons were
   a. not licensed
   b. indifferent to the suffering
   c. inadequately equipped
10. The author implies that Andersonville Prison was surrounded by
    a. a large swamp
    b. confederate camps
    c. a high wall
Appendix C: Verbal Instructions Script

This study looks at different designs of reading activities. You will be asked to read online text with an animated character and answer some questions. Please, pay attention to the character since you will be asked questions about it. Don’t worry. This is not a test. It will not affect your grade and all data collected is anonymous.

Give out consent forms (ahead of time if possible).

Please take a few minutes to review the consent form. It is yours to keep. If for any reason you cannot participate in this experiment or if you have already done it then please let me know.

Wait for a few minutes.

I will shortly ask you to pick a card from a container. Each card contains a login. The password will be the same as your login.

For this activity, you will have about 40 minutes to read 4 pages of text and answer a number of multiple-choice questions at the end. You will not have to type anything. Please read each page completely before moving on to the next page since you will not be able to go back. I repeat, you will not be able to go back to previous pages, so finish reading each page before clicking on the arrow.

Any questions? Are you ready?

Please, put your headphones on and enter your login and password. You should hear voice instructions on the first page. If you do not, just raise your hand. Please, do not start the experiment until I tell you to. Ok?
Appendix D: Informed Consent Form Text

Informed Consent to Participate in Research
Information to Consider Before Taking Part in this Research Study

Pro # Pro00027476

Researchers at the University of South Florida (USF) study many topics. To do this, we need the help of people who agree to take part in a research study. This form tells you about this research study. We are asking you to take part in a research study that is called: The Effects of Arousal Presented by a Pedagogical Agent on English Language Learners’ Situational Interest, Cognitive Load and Reading Comprehension in Online Reading Tasks – Attention Arousal in Online Reading Tasks (AAORT). The person who is in charge of this research study is Jack Drobisz. This person is called the Principal Investigator.

Purpose of the study

The purpose of this study is to examine student perceptions of different types of electronic texts, which include animated characters and voice narration.

Why are you being asked to take part?

We are asking you to take part in this research study because we are trying to make online reading more interesting to students.

Study Procedures:

If you take part in this study, you will be asked to participate in a single computer based activity, which includes an online survey. This activity will take no more than one hour of your time and will take place during your regular class period.

Alternatives / Voluntary Participation / Withdrawal

You have the alternative to choose not to participate in this research study. You should only take part in this study if you want to volunteer; you are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study. Your decision to participate or not to participate will not affect your student status or course grade.

Benefits and Risks

We are unsure if you will receive any benefits by taking part in this research study. This research is considered to be minimal risk.

Compensation

We will not pay you for the time you volunteer while being in this study.
Privacy and Confidentiality

It is possible, although unlikely, that unauthorized individuals could gain access to your responses. Confidentiality will be maintained to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet. However, your participation in the online survey involves risks similar to a person’s everyday use of the Internet. If you complete and submit an anonymous survey and later request your data be withdrawn, this may or may not be possible as the researcher may be unable to extract anonymous data from the database.

Certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are: the research team, including the Principal Investigator and the advising professor, as well as the University of South Florida Institutional Review Board (IRB).

Contact Information

If you have any questions about your rights as a research participant, please contact the USF IRB at (813) 974-5638 or contact by email at R SCH-IRB@usf.edu. If you have questions regarding the research, please contact the Principal Investigator at (813) 974-9785 or contact by email at jack@usf.edu.

We may publish what we learn from this study. If we do, we will not let anyone know your name. We will not publish anything else that would let people know who you are. You have been given a copy of this form.

I freely give my consent to take part in this study. I understand that by proceeding with this reading activity and following survey that I am agreeing to take part in research and I am 18 years of age or older.
Appendix E: Experiment Journal and Notes

A small pilot study was conducted on November 09, 2016 in a computer lab. Four males and three female students (n=7) participated in the pilot, which verified average time required to read four pages and answer all questions to be about 30 minutes. One of the conditions was broken (malformed XML) which was subsequently fixed. There were also some minor corrections and clarifications that were added to instructions. In addition, new voices were recorded using a live actor to stress the emotional tone in high perceptual arousal conditions. Appendix C contains instructions which were read to each group at the beginning of each of the 13 experimental sessions that followed.

The first experiment (EE5) took place on November 14th, 2016 at 12:30 PM. Six female and two male participants (n=8) completed the activity in about 35 minutes. Once of the male students was observed using his cell phone to look up some vocabulary words. The second experiment (AP4) was on November 15th at 9:30. Seven male and five female participants started the activity but one female student felt sick and left after a few minutes (n=11). One of the male students was observed going back to Google to look up words. The room was a bit warm and students had to take a vocabulary test afterwards. The third experiment (EE5) commenced on November 16th at 12:30 PM. Only 6 students participated (n=6): 2 female and 4 male. One of the female students came in 30 minutes late. One of the male students was eating a sandwich. The fourth and fifth experiments (AP4) took place on November 29th at 9:30 in EDU lab. Twenty-one students from two classes participated but two of them were disqualified since they already did this activity before (n=19). Several female and male participants were observed using smart phones or browser to look up words. The sixth experimental sessions (EE5) took place on November 30th at 12:30. 6 male and 5 female students participated (n=11). 2 male students finished the activity in less than 15 minutes. 2 students were late. The seventh experiment (US6) took place on December 6 at 2:00 in EDU lab. Only 3 female and 1 male (n=4) students participated. One male student took a long time to complete the activity and the instructor played class video on the overhead before he was finished.

Because only n=59 student participated in the fall of 2016, the experiments were continued at the beginning of the 2017 spring semester. Since many subjects failed the manipulation check the following sentence was added to verbal instructions: “Please, pay attention to the character since you will be asked questions about it.” In addition, to reduce a
possibility of students repeating the experiment, the following sentence was inserted into instructions: "…or if you have already done it…"

The eight experiment (AP4) was conducted on January 26th, 2017 at 8:00 with 5 male and 5 female students (n=10). All students finished in about 25 minutes. The ninth experiment (US6) took place on January 26th at 12:30. Only 3 students qualified since most claimed to have done this activity in a prior semester (n=3). The tenth experiment (AP4) took place on January 30th at 9:30. 7 male and 2 female students participated (n=9). One of the female student exited page 1 before and was forced to continue from page 2. The 11th experiment (AP4) was conducted on January 31st at 9:30. The lab was very hot. 4 female and 8 male students participated (n=12). 2 of the students exited prematurely and had to log in again. Some students were observed to use their phones to look up words. One of the students took almost 50 minutes to finish the activity. The 12th, 13th and 14th experiments (EE5) took place in two adjacent labs on February 2nd at 12:30. Lab A had 2 groups consisting of 9 male and 10 female students while lab B hosted 5 male and 5 female student (n=29). One of the female students came in late and claimed to have done this activity before. She was excluded. One of the student reported not hearing any sound at all (166). The 15th, 16th and 17th experiment sessions were conducted on February 2nd at 8:00 in two adjacent labs. Lab A had 2 groups consisting of 15 male and 7 female students while lab B hosted 10 male and 1 female students (n=33). One of the female students in lab A came in late and left early. One of the male students left the lab for about 25 minutes in a middle of a text page. The final 18th experiment (US6) took place on February 2nd at 12:30. Only 2 male and 2 female students (n=4) participated. Other students claimed to have done this activity before. The US6 student appeared more engaged and curious. They seemed to struggle less with the reading activity and volunteered more feedback at the end. For example, one of the female students suggested that whoever designed the pedagogical agent should "improve their animation skills" (she was in a low perceptual arousal condition). One of the male students expressed being "bored" by the character but also reported that background helped him "visualize the content of the stories."

After a total of 13 experimental sessions (with 18 classes) data from 159 students was collected. One of the students did not finish the experiment and one of the students, id=198 reported to be under 18. Both of them were subsequently removed from a data set (n=157). In early data analysis it became evident manipulation check responses were not as accurate as
expected. It is possible that "decorative background” might have been confused with “background related to text.” Also, in low INQA condition, “continue reading” might have been interpreted as “sounded bored.” Several students checked “didn’t say anything” and then “sounded bored” which is a potential conflict. “Only gave directions” and “talked about the topic” might have also been confusing. Overall, it appears that most students did not pay enough attention to the APA – possibly because this was presented as a reading activity. It would be interesting to see how this differed between different levels – AP4, EE5 and US6 but unfortunately these populations were not evenly distributed (US6 was only n=7).
### Appendix F: SPSS ANOVA Between-Subjects Effects Tables

#### Two-way analysis of variance for situational interest

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<thead>
<tr>
<th>Source</th>
<th>df</th>
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<th>F&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p&lt;sup&gt;c&lt;/sup&gt;</th>
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<tr>
<td>Perceptual arousal (two levels)</td>
<td>1</td>
<td>0.011</td>
<td>0.017</td>
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<td>Inquiry arousal (two levels)</td>
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<td>Error</td>
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<td>0.636</td>
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</tr>
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*Note.* <sup>a</sup> MS: Mean Square.  <sup>b</sup> F: F statistics.  <sup>c</sup> p: Significance level.

#### Two-way analysis of variance for intrinsic cognitive load

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<tr>
<td>Perceptual arousal (two levels)</td>
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<td>8.465</td>
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<td>Inquiry arousal (two levels)</td>
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<tr>
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<td>7.071</td>
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<tr>
<td>Error</td>
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<td>4.180</td>
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*Note.* <sup>a</sup> MS: Mean Square.  <sup>b</sup> F: F statistics.  <sup>c</sup> p: Significance level.

#### Two-way analysis of variance for extraneous cognitive load

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<tbody>
<tr>
<td>Perceptual arousal (two levels)</td>
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*Note.* <sup>a</sup> MS: Mean Square.  <sup>b</sup> F: F statistics.  <sup>c</sup> p: Significance level.

#### Two-way analysis of variance for germane cognitive load

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<td>27.138</td>
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*Note.* <sup>a</sup> MS: Mean Square.  <sup>b</sup> F: F statistics.  <sup>c</sup> p: Significance level.  *p < 0.05.*

#### Two-way analysis of variance for reading comprehension

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</table>

*Note.* <sup>a</sup> MS: Mean Square.  <sup>b</sup> F: F statistics.  <sup>c</sup> p: Significance level.  *p < 0.05.*
Appendix G: IRB Approval

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

10/4/2016

Jack Drobsz, Ph.D.
USF Information Technology
4202 E Fowler Ave
Tampa, FL 33620

RE: Expedited Approval for Initial Review
IRB#: Pro00027476
Title: The Effects of Arousal Presented by a Pedagogical Agent on non-English Speakers' Situational Interest, Cognitive Load and Reading Comprehension in Online Reading Tasks.

Study Approval Period: 10/4/2016 to 10/4/2017

Dear Dr. Drobsz:

On 10/4/2016, the Institutional Review Board (IRB) reviewed and APPROVED the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
drobsz-pro00027476-protocol.docx

Consent/Assent Document(s)*:
drobsz-pro00027476-consent(no_signature).docx

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s). **Coversheets for surveys are not stamped.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:
(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

\[\begin{array}{c}
\text{John Schinka, Ph.D.}
\end{array}\]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board