An Eye Tracking Study to Investigate the Influence of Language and Text Direction on Multimedia

Arwa Adulwahab Mashat
Old Dominion University, arwa814@hotmail.com

AN EYE TRACKING STUDY TO INVESTIGATE

THE INFLUENCE OF LANGUAGE AND TEXT DIRECTION ON MULTIMEDIA

by

Arwa Abdulwahab Mashat
B.S. June 2004, King Abdulaziz University, Saudi Arabia
M.S. May 2009, Youngstown State University

A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirements for Degree of

DOCTOR OF PHILOSOPHY

INSTRUCTIONAL DESIGN AND TECHNOLOGY

OLD DOMINION UNIVERSITY
MAY 2017

Approved by:

Ginger Watson (Director)

Shana Pribesh (Member)

Jill Stefaniak (Member)

ABSTRACT

AN EYE TRACKING STUDY TO INVESTIGATE
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Arwa Abdulwahab Mashat
Old Dominion University, 2017
Director: Dr. Ginger Watson

This study investigated how native language orientation influences spatial bias, first visual fixation on screen, first visual fixation on pictures, learning outcomes, and mental effort of learners. Previous studies supported the effect of native language writing or reading direction on spatial bias, examining written text and images created by the participants (Barrett et al., 2002; Boroditsky, 2001; Chatterjee, Southwood & Basiko, 1999; Spalek & Hammad, 2005). However, no study investigated writing direction in multimedia presentations using eye tracking. This study addresses this gap.

A total of 84 participants completed the study forming four groups. The first group (NativeLeft_InstrEng) consisted of individuals whose native language is written from left to right and who have never experienced a right to left language. They received the material in English. The second group (NativeRight_InstrAra), whose native language is written from right to left, received the material in Arabic. The third group (NativeLeft_LrnRight_InstrEng) consists of individuals whose native language is written from left to right and who are learning or have learned a language written from right to left. They received the material in English. The fourth group (NativeRight_InstrEng), whose native language is written from right to left, received the material in English. Participants were asked to complete a survey that consisted of eight sections: demographic questions, self-estimate prior knowledge test, the instructional unit, mental effort rating, sentence forming questions, recalling questions, sequence question and finally, post-test

questions. Eye tracking was used to detect first fixation on screen and pictures, and results were compared with participants' written responses. Eye movements can be considered the blueprint for how students process the visual information (Underwood & Radach, 1998).

Significant results for learning and spatial bias confirmed that spatial bias is associated with native language orientation such that the left-oriented learners were more likely to demonstrate left bias on the screen, while participants who were right-oriented demonstrated right bias. However, exposure to other languages, culture, or beliefs; or living for some time in a country which uses a language with a different orientation can influence learner's spatial bias, as seen with group NativeRight_InstrEng. Finally, differences in visual fixations on screen and pictures were not significant perhaps due to the simplicity of pictures used in this study.

I dedicate this dissertation to my loving parents who were there in every step of my journey. They felt my stress, emotions and my thoughts before I even said a word. Their prayers guided me to the end. Without them, I would not have successfully completed my graduate degrees.

I also dedicate this dissertation to my supportive husband, Faisal, who never left my side and encouraged me during my weakest moments. And to my children, Mariah, Sarah and Abdallah who kept me busy, but were my motivation throughout this journey.

A special gratitude to my sisters and brother, Ala, Afnan, Azhar, Afrah and Mohammad. They helped me during my busiest moments and were there when I needed them the most. I would not be who I am today without the love and support of my family.

ACKNOWLEDGMENTS

There are many people who have contributed to the successful completion of this dissertation. Throughout my graduate education, Dr. Ginger Watson has been a great mentor and teacher. She guided me through my courses and research, helped me revise my writing, and gave advice and encouragement throughout the pursuit of my degree.

I would like to express my gratitude to Dr. Shana Pribesh for her support and help toward forming my proposal. I would also like to thank Dr. Jill Stefaniak for her comments and revisions of my research.

I will always owe a great deal of gratitude toward these professors who provided guidance, knowledge and advice.

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CHAPTER I

INTRODUCTION

People learn every day, but each person learns differently. The learning process can be influenced by culture, country, religion, and language. These factors affect both when and how people learn. Cultural issues (beliefs, traditions, values, patterns) are an efficient way to determine the effectiveness of instructional materials (McAnany, 2009). Some graphic representations, symbols, or images may have different meaning in different cultures. Integrating multiple cultures in education is important for creating a learning environment that is suitable for all students (Chen et al., 1999). When cultural considerations are not factored in the instructional design process, learning might be compromised for learners from other cultures, as they might learn in a different way (Blunt, 2006). To create effective instructional materials, designers need to ensure the relevance of the instructional message, which is challenging when designing for multiple cultures (McAnany, 2009).

There are around 7,000 spoken languages in the world. Languages are different in letters, pronunciation, grammar and writing systems. Some written languages go from left to right, such as English, French, and Latin. Other written languages may go from right to left such as Arabic, Farsi, Hebrew, and Urdu; from top to bottom such as Chinese, Japanese and Korean; or from bottom to top such as Ancient Berber. Some languages can even be written in multiple directions. Language and culture differences have been found in the way numbers are represented spatially on a line, and in the way the order and duration of events is described (Fuhrman & Boroditsky, 2007).

Several studies have concluded that the writing direction of a person's native language influences a person's spatial bias (Spalek & Hammad, 2005; Dobel, Diesendruck & Bolte, 2007). This bias can also influence the way people learn. Christman and Pinger (1997) not only found that people prefer arranging events from left to right, but also do so when arranging pictures. This can be an important issue to consider when designing material for different audiences.

Technology and computers have been important tools for learning and accessing media. Multimedia learning has played a big role in how people learn and think (Mayer, 2010). Words, images, video and audio can be combined to present a learning message. Mayer (2009) defines multimedia instruction as the presentation of text combined with pictures to promote learning. However, simply presenting multimedia on computers does not necessarily improve learning; it is the design of instruction itself that improves learning (Clark, 1994).

McFarland (1995) presented some guidelines when designing multimedia. Learners need to engage and link the material presented to the existing knowledge in memory. Using the appropriate images with text can form this connection. Message design addresses the presentation part of the instructional process (Fleming & Levie, 1978). Identifying how the learners process the message is an important aspect of designing the learning experience. Message is described as the pattern of signs to modify cognition, behavior and psychomotor of a person. Some cultures may misinterpret the message.

Knowing the target audience is one of the main factors in designing multimedia (Lu, 1998). It is important because it will help instructors understand the student's learning environment and therefore create better learning outcomes. This may indicate that instructional designers need to consider native language writing direction when designing material. Designing for learners that are different from the designer can be overwhelming. Designers are usually influenced by their own environment (Lu, 1998), so it is a challenge for them to identify learners' cultural attributes. Cultural attributes can be identified as beliefs, religion, traditions, values, actions, etc. Designers need some background about their learners to ensure that they receive the instructional message without offending anyone (McAnany, 2009). However, it is important to find out whether or not languages influence how people learn because it might affect the learner's cognitive capacity. A design that requires greater mental effort can result in less learning. Inappropriate instructional design can generate extraneous cognitive load. Increasing the amount of working memory that a learner must expend, hinders learning. This is undesirable and can be controlled by the designer or instructor (Chen et al., 2009).

Cognitive Load Theory (Sweller & Chandler, 1991) focuses on how the human mind processes information, especially working memory, and should influence the decisions about designing multimedia materials. Cognitive load can be reduced by placing the images near the text as suggested by the spatial contiguity principle. This also helps to avoid split attention where material is displayed in different pages or screens (Mayer, 2009). Unfortunately, there has not been any recommendation on how to arrange images with text according to different languages.

The purpose of this study was to determine whether language writing orientation influences the design of multimedia material. Using tasks and eye tracking measures, the study investigated the following: 1) learner's spatial bias, 2) learner's first visual fixation on screen, 3) learner's first visual fixation on pictures, 4) learner's learning outcomes, and 5) learners' mental effort.

This study was intended to help instructional designers who design multimedia presentations for a bilingual audience, and thus focused on participants using or learning a second language that differs, in its writing orientation, from that of their native language. A great message with good instructional design will attract attention, and be understood, remembered, and more readily retrieved (Seels et. al, 1996).

Delimitations

The study considered a group of participants learning a second language, different in its writing orientation than their native language (either left to right or right to left). It did not consider individuals learning other languages with the same orientation as the participant's native language nor any languages written from top to bottom or bottom to top.

CHAPTER II

LITERATURE REVIEW

Multimedia presentations are presentations that include pictures with words to foster learning (Mayer, 2009). Though multimedia elements can assist, it is ultimately the design of instruction that improves learning (Clark, 1994). Building on these premises, this study was conducted to help instructional designers arrange and design material for multi-language audiences to optimize learning outcomes. It examined how languages influence learning from multimedia presentations and used eye movements to indicate learners' visual attention, learning, mental effort, and spatial bias. This literature review focused on six sections that emerge with multimedia. The sections are: multimedia learning, cognitive load of multimedia learning, language, culture, spatial bias and eye tracking.

Multimedia Learning

Mayer (2009) presented different contexts of multimedia such as multimedia learning, multimedia presentation, multimedia instruction and multimedia message. However, they all share the concept of combining words with pictures. Multimedia is found and integrated in educational and instructional settings. Multimedia can be a combination of two or more media such as text, images, audio or video. Mayer (2009) stated that learning is better facilitated when spoken or written text and pictorial representations are combined than when text alone is used. Pictorial representations can be either static or dynamic in the form of pictures, diagrams, graphs, animations or videos. However, designing and arranging words with images can be challenging for instructional designers.

A well-designed multimedia presentation is organized efficiently and integrates learners' prior knowledge. It draws learners' attention to text and images and increases the learners' level of engagement (Slykhuis, et al., 2005). Adding too much text or images can overwhelm the learner and result in a negative learning experience causing work overload. This means that learning does not always occur when text is added to a picture and can even reduce the learning process (Mayer, 2003).

A major consideration when combining words with pictures is the placement of each media form. The spatial contiguity principle assumes that placing the text near pictures will avoid split attention and result in deeper learning than when text is placed far from pictures or placed on separate pages or screens (Mayer, 2009). Consequently, designers need to consider the location of the verbal and pictorial representations to enhance learning and improve performance.

Cognitive Load of Multimedia Learning

Another major consideration regarding combining words with pictures is how much information should be added to a single page or screen. This relies on how much information the human mind can process. Both Cognitive Load Theory (Sweller & Chandler, 1991) and Mayer's Cognitive Theory of Multimedia (Mayer, 2009) focus on how the human mind processes information, especially through the working memory, which influences the decisions about designing multimedia materials. According to Mayer (2009), human minds process written words and pictures into the working memory through the eyes, and spoken words through the ears (Figure 1). Working memory is known to be limited and able to hold and manipulate a limited amount of information. When information is organized and integrated with prior knowledge, it will be moved into long-term memory and learners will be able to retrieve it afterwards. However, retrieving stored information can be difficult. Exceeding available working memory space can cause overload and effective learning will not occur (Sweller & Chandler, 1991).

Previously conducted studies present several ways to measure the cognitive load and mental effort caused by instructional material in multimedia learning such as transfer tests, cognitive load measures, and time on task (Van Gog & Scheiter, 2010). However, individual differences play a huge role in multimedia learning (Chen, 2009). There are many factors that can affect learning and cognition, such as religion, beliefs, culture, and language (McAnany, 2009).

Language

Language is a tool with which learners experience and comprehend the world. Lu (1998) suggested knowing the target audience when designing multimedia for an international audience and recommended avoiding the English-as-the-only-language attitude.

Plass, et al. (1998, 2003) did a study on English speaking students learning German. Students received no annotations, verbal (text) annotations, visual annotations or both while studying a story. Results showed that students learn better when accessing both verbal and visual modes of material. However, if students had to select one mode, they indicated that visual modes would be more beneficial than verbal modes. These results were consistent with multimedia learning and cognitive load theories, which assume that learning is processed under limited capacity. Findings also emphasized the importance of individual differences and preferences.

Winn and Holiday (1982) presented a diagram of dinosaurs from left to right and top to bottom, having the dinosaurs facing left to right to a group of students. They presented the reverse diagram going from right to left, bottom to top, to a second group. They found that the first group was more successful in learning. The second group did no better than the control group who was not presented with a diagram. These results suggest that the habit of reading from left to right is strong and presenting materials to learners in reverse went against their logic and prevented them from learning.

Maass and Russo (2003) stated that English speakers tend to prefer images that involve motion from left to right. The most logical explanation for the predominant scanning habit in the American culture was that English is written and read from left to right. People can be influenced by this natural habit even for tasks that do not involve writing or reading. A conclusion might be drawn that the reverse could also be true: the predominant scanning habit in the Arab culture is right to left, since Arabic is written and read from right to left.

Spatial Bias

There is evidence that artwork, posing, portraits and advertisements have a leftward bias from several time periods. This can be explained by the neurobiological mechanisms that generate attentional and perceptual biases (Friedrich & Elias, 2016).

Mass and Russo (2003) studied directional bias in Italian and Arab students. There were four groups: 1) Italian students who responded in Italian, 2) Arab students whose native language is Arabic, but who are living in Italy and respond in Italian, 3) Arab students whose native language is Arabic, but are living in Italy and respond in Arabic, and 4) Arab students whose native language is Arabic, but are living in their Arab countries and respond in Arabic.

Participants read four simple sentences and drew a scene. Verbs in the sentences implied a subject to object motion. Results showed a left bias for Italians and a right bias for Arabs living in their home country. However, there was a reliable correlation between years spent abroad and bias. Arabs who spent more years outside their home country tend to have lower right positioning bias than Arabs living in their home country.

Chokron & De Agostini (2000) compared French and Hebrew adults and third graders on aesthetic preferences. They found that French adults preferred pictures with left to right direction and the Hebrew adults preferred the opposite direction from right to left according to their native language writing direction. The third graders from each group showed the same results, but not as significant as the adults. They suggested that writing direction effects aesthetic preferences and gets stronger as users gain more experience.

McCrink & Shaki (2016) asked English and Hebrew adults to recall information from arbitrary pairings in the center of a screen, that were either consistent or inconsistent with the group's writing direction. Both groups recalled more information (letters of the alphabet) when it was consistent with their writing direction (culturally spatial flow). The results indicate cultural influences on the correlation between spatial attention and ordinal position. In addition, image recall, visual attention and sequential arrangements of English, Chinese and Taiwanese speakers were investigated by Chan and Bergen (2005). They found that writing direction affects cognition by the way learners remember, visualize and arrange items.

Further research is needed to explore whether designers should consider bias according to written language text direction when designing multimedia material. Previous studies have supported the effect of native language writing or reading direction on spatial bias, examining written text and images created by the participants (Barrett et al., 2002; Boroditsky, 2001;

Chatterje et al., 1999; Haun et al., 2011; Kazandjian et al., 2010; Lovett & Forbus, 2011; Spalek & Hammad, 2005). These studies, however, have not examined multimedia instructional materials.

Eye Tracking

Eye tracking is a method to investigate whether spatial bias has an effect on learning. It can help inspect visual attention and track eye movements between text and images when individuals are presented with instructional material.

Recent research on multimedia instruction has shifted from focusing on the delivery process to the cognitive process. It is difficult to measure students' attention, cognitive load, and visual patterns in learning environments (Chauang & Liu, 2012); however, eye tracking is a method that can help analyze learners' interaction and attention with the representations in multimedia learning (Chauang & Liu, 2012; Slykhuis et al., 2005; Van Gog & Scheiter, 2010). Eye movements can be considered the blueprint for how students process the visual information (Underwood & Radach, 1998). Learners' attention is usually focused on a certain part of the page or screen and they give priority to information presented according to spatial locations (Jiang & Swallow, 2013).

Eye tracking measures. Eye fixation is one of the eye tracking measurements. Fixation is the eye's period of stability when focused on a point of interest, and indicates that the information has processed cognitively into the long-term memory (Chauang & Liu, 2012; Slykhuis et al., 2005). It is also believed that the number and frequency of fixations is related to learner's searching for information (Szlichcinski, 1979). The cognitive process and the eye fixation are referred to as the "eye-mind" assumption. If movements were scattered and fast between one point and another, then it can be assumed that no information was processed by the cognitive system. The number of fixations can be related to the viewer's efficiency in searching for relevant information. The frequency of a viewer's fixations on a specific element or area reflects its importance. The duration of the fixation may indicate the difficulty of the element or task (Chauang & Liu, 2012). It has been found that experts tend to fixate faster on relevant information than novices do (Van Gog & Scheiter, 2010). Smith & Elias (2013) found during a visual search task, that left to right readers identified targets faster in the left upper corner, but right to left readers showed no difference for targets placed on either the left or right upper corner. They concluded that location of attention and initial fixation is influenced by reading direction.

Johnson and Mayer (2012) present three types of eye tracking measures of cognitive processing during learning. The first measure is *integrative transitions*, which is the total number of times fixation shifts from text to image or vice versa. The second measure is *text-to-diagram transitions*, which measure the number of times the learner's fixation shifts from text to image. (Shifts from image to text are not included in this measure.) The basis for this is prior research, which indicated that students use text to guide their processing of the accompanying images. The third measure is the *corresponding transitions*, which is the total number of fixation shifts from text to a part of the image that corresponds to the text. This measure, however, does not indicate whether the learner actually made any cognitive connections, which is considered a general limitation in eye tracking. It is better if it is complemented with a performance test or a comprehension test (Hyona, 2010; Johnson & Mayer, 2012).

Previous studies using eye tracking. Eye tracking has helped answer how students interact with different representations and how these interactions influence learning and visual attention (Van Gog & Scheiter, 2010). Chuang and Liu (2012) used eye tracking to investigate the effects of the arrangement of text and pictures on information processing and cognitive load. Two multimedia presentations were presented to the participants. The first presentation consisted of five successive web pages explaining wind formation over land. However, the other presentation was a single page on the formation of wind over sea. Both presentations had illustrations and the same number of words. The researchers compared participants' processing of text and images by analyzing the number and duration of fixations. Results showed that the number and duration of fixations on the text area were the same on both presentations. However, the number and duration of fixations on images was greater for the multiple pages presentation. They found that learners spent more mental effort when images were related to the text content and drew students' attention away from the text. Mayer (2009), however, argued that breaking information into small chunks helps student understand the content. This study found that students had higher cognitive load when the presentation was divided into segments rather than one single page. This can be a result of what Sweller (2005) defined as split attention, when separating related information into several pages and Mayer's (2009) spatial contiguity principle. This study found better results were achieved when the amount of text was downscaled and was more relevant to the picture.

Johnson and Mayer (2012) also used eye tracking to study the spatial contiguity principle. Participants examined a single multimedia slide presentation that consisted of words and images explaining how a car's brake system works. The first *integrated* group had the text and images near each other, whereas the *separated* group received the same material with the text and images located far from each other. Results showed that the integrated group performed better in the transfer test and made more integrative transitions and corresponding transitions, which indicates that spatial contiguity encouraged learners in making connections between words and pictures. This is likely due to the fact that participants did not need to scan the screen in order to find the relevant information. An important conclusion was that learning was more text directed, meaning that learners focus on text more than images.

Summary

There are many ways that learners can experience instructional material. They can read the text first then look at the image or they can look at the image and then read the text or they can go back and forth between the text and image to make connections (Van Gog & Scheiter, 2010). Previous research has shown that students' learning is enhanced when pictures are added to words and when words and pictures are presented near each other. It has also been indicated that multimedia learning helps students learn a second language. Many studies lately have been using eye tracking to track learners' attention and interaction with instructional material. Learners usually spend more time reading text than inspecting the visuals; however, they spend more time inspecting the visuals when text was spoken than when written (Schmidt-Weigand et al., 2010).

Purpose of Research

A review of the literature found relevant studies clustered into language bias studies for instruction/multimedia and eye tracking studies for instruction/multimedia. None of the studies dealt with language orientations where direction was a study variable in instruction/multimedia with eye tracking. The purpose of this study is to fill this gap in research and investigate the influence of language orientation or direction on learning, perceptions, and visual attention when learners are using computer-based multimedia presentations. Language is one of the important cultural attributes that instructional designers need to consider when designing. It can shape learning by the way learners process the information visually or mentally. This study is intended to help instructional designers to design for learners with different languages. Considering a learner's language attributes when designing can help increase attention and therefore minimizing learning time. A focus was on the use of eye tracking learners' eye movements through the eye tracker to determine learner's attention and bias. Learners using materials in Arabic and learners using materials in English were observed. This study might help web designers when developing websites for multiusers with different languages. This can be applied to applications for iPads and tablets. Overall, the study would be helpful in designing for many technology devices either for learning or entertainment. This study will address the following research questions.

Research Questions

1. Does a person's native language text orientation influence spatial bias?
2. To what extent does native language text orientation influence learner's first visual fixation on the material presented, text versus pictures, on screen?
3. To what extent does native language text orientation influence the way learner's visual fixation varies for pictures on screen?
4. To what extent does native language text orientation influence the learning of content?
5. To what extent does native language text orientation influence mental effort for learners with different spatial orientations?

CHAPTER III

METHOD

Participants

A total of 89 participants completed the study. Five participants' data were excluded due to incomplete or missing eye tracking data files. The remaining 84 participants (37 male, 47 female) completing this study were categorized into four different groups. Participants were recruited from a mid-Atlantic university. Recruitment was by advertisement and emails to the entire university focusing on the English language institute and foreign classes.

- In the (NativeLeft_InstrEng) group, participants' native language is written from left to right and the individuals had never experienced a language from right to left. They received the material in English (N=27).
- The (NativeRight_InstrAra) group participants' native language is written from right to left and they received the material in Arabic (N=20).
- The (NativeLeft_LrnRight_InstrEng) group participants' native language is written from left to right and they are currently learning or have learned a language written from right to left. They received the material in English (N=20).
- The (NativeRight_InstrEng) group participants' native language is written from right to left and they received the material in English (N=17).

Participants were either students, faculty or staff from the university. They were placed in each group according to their native language and second language if it was written from right to left.

A complete description of the demographic data for each group regarding gender, age, degree, location, language, right/left handed, eye wear and average completion time of experiment is presented in Table 1. Female participants were higher across all groups except for the NativeRight_InstrEng group where male participants were higher in participation. Most participants' age ranged from 21- 30 years old but in the NativeRight_InstrAra group 55% were from age 31-39. For educational degree, group NativeLeft_LrnRight_InstrEng had higher percentage of some university education where the other groups had higher percentages of graduate degree participants.

Regarding living location, participants were asked if the USA was their home country and it was 59% for NativeLeft_InstrEng, 0% for NativeRight_InstrAra, 85% for NativeLeft_LrnRight_InstrEng and 18% for NativeRight_InstrEng. Although the groups with a native language written from right to left were from other countries than the US, 15% from the NativeRight_InstrAra group and 24% NativeRight_InstrEng learned English since birth.

Being right or left handed was not an issue between groups. The majority of the participants were right handed. Although many did not wear eye glasses or contacts, there were some participants that did. The eye tracking device was compatible with eye glasses and contacts and did not interfere with the results.

Table 1

Demographic Data

Demographics		Group			
		NativeLeft_ InstrEng	NativeRight_ InstrAra	NativeLeft_ LrnRight_ InstrEng	NativeRight_ InstrEng
Gender	female	16	13	13	5
	male	11	7	7	12
Age	18-20	4%	0	35%	18%
	21-30	41%	45%	40%	47%
	31-39	22%	55%	15%	24%
	40-49	22%	0	5%	6%
	50-59	7%	0	5%	0
	60+	4%	0	0	6%
Degree	High School	0	0	15%	0
	Some university	11%	0	45%	12%
	Diploma	0	0	5%	12%
	Bachelor	19%	25%	25%	6%
	Graduate	70%	75%	10%	71%
Location	USA is their home country	59%	0	85%	18%
	Never lived outside the US	48%	0	75%	6%
	Lived outside the US for 5+ years	41%	90%	10%	71%
Language	Speak English at home	63%	10%	75%	24%
	Learned English at birth	70%	15%	95%	24%

Demographics		Group			
		NativeLeft_ InstrEng	NativeRight_ InstrAra	NativeLeft_ LrnRight_ InstrEng	NativeRight_ InstrEng
Handed	Right	96.3%	90%	95%	100%
	Left	3.7%	10%	5%	0%
Eyes	Glasses	40.7%	15%	25%	35.3%
	Contact Lenses	7.4%	10%	40%	5.9%
	None	51.9%	75%	35%	58.8%

Research Design

The study utilized a quasi-experimental design. The study investigated the following: 1) learner's spatial bias, 2) learner's first visual fixation on screen, 3) learner's first visual fixation on pictures, 4) learner's learning outcomes, and 5) learners' mental effort.

The four groups represented the independent variable. Each group (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) reflected their native language writing orientation, the language learned (if applicable) and the language in which they received the instructional material. Dependent variables included spatial bias, visual fixation, learning and mental effort.

Spatial bias. This dependent variable was a combination of the sentence-forming task, the recalling task, and the sequence task. These tasks came after the instructional unit and before the post-test question to wipe any data in short-term memory and give more reliable answers in the post-test. Spatial bias was determined through the written responses and the eye-tracking data collected for the three tasks.

First, the sentence forming task (Appendix F), participants were presented with three pairs of pictures and were asked to write a sentence using both pictures without using (and, or) connectors (Chan and Bergen, 2005). The aim was to see what participants select as the subject and which as the object. If the picture (on the right) was selected as the subject then their attention was focused towards the right, but if the picture (on the left) was selected then their bias was towards the left. This may relate to their native language writing orientation. To determine the bias in the sentence-forming task (Figure 2), if the learner used the left image (shown in the red rectangle) as the subject in the sentence then it was coded as left (1), but if the learner used the right image (shown in the blue rectangle) as the subject it was coded as right (2) for both the writing and eye tracking parts. An average of the points for each pair of pictures was calculated. This activity was similar to the drawing task that Barrett et al. (2002) applied in their study.

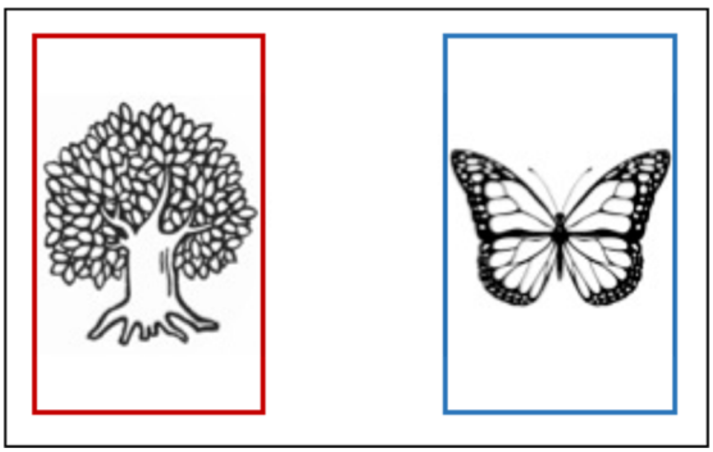

Figure 1. Regions of Sentence Forming Task

Second, in the recalling task (Appendix G) participants were presented with two screens. The “Screen of Words” consisted of 16 words arranged in four rows and four columns. The participants were asked to look at the screen only. The other, “Screen of Images” consisted of eight small images forming a pictorial view. Also, the participants were asked to look at the screen only. After completing the next task (sequence task question), they were asked to list at least three of the words and three of the images they recall from the screens. The reason for delaying the question was to wipe any data from short-term memory. However, to determine the bias in the recalling task for the writing part (Figure 3, 4), the listed words and images were each counted according to being on the left or right side of the screen. If the items from the word list were more from the left (shown in the red rectangle), then (1) was given. If the items from the word list were more from the right side of the screen (shown in the blue rectangle) then (3) was given. If they recalled equally from both sides, then (2) was given. For the eye tracking part, if the number of fixations was more on the left it was coded as (1), but if it was more on the right it was coded (2).

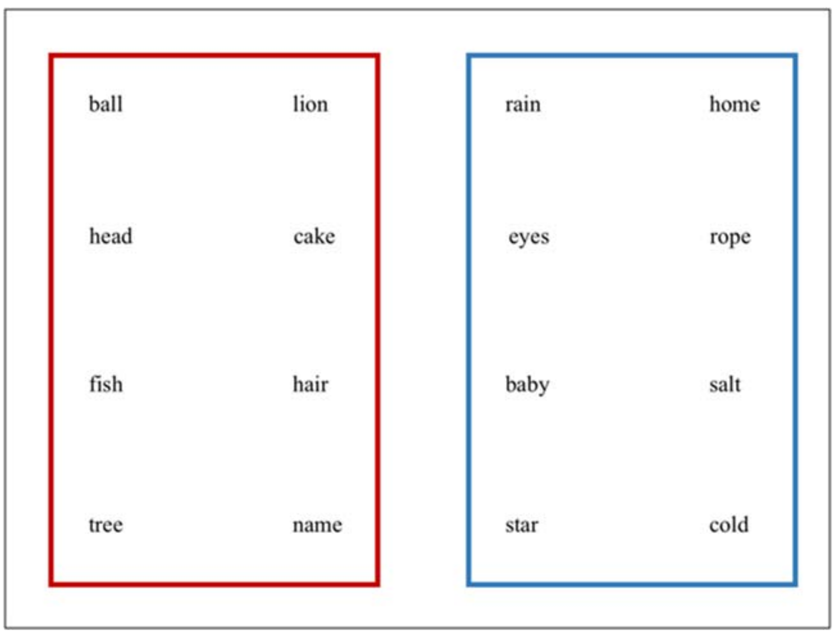

Figure 2. Regions of Word Recall Task

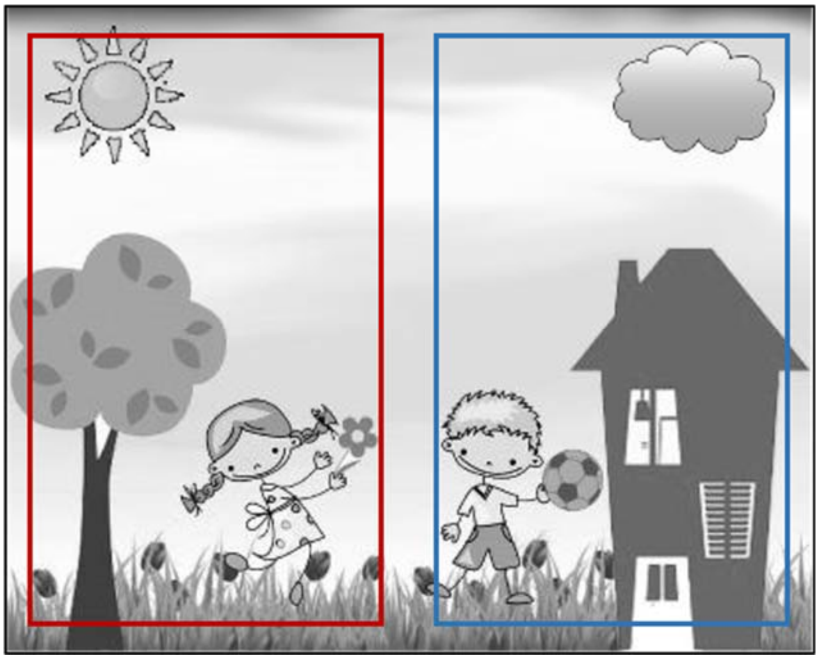

Figure 3. Regions of Image Recall Task

Third, the sequence task (Appendix H) presented three black and white pictures beside each other. There were no text or arrows describing the pictures. If the pictures were processed from left to right it would show a dirty shirt being cleaned but if it was processed from right to left it would show a clean shirt becoming dirty (Figure 5). Participants were asked to explain what they saw in the pictures. Finally, determining the bias for the sequence task depended on how the participant explained in writing the three sequenced images. If they started from the left (shown in the red rectangle), they were given (1), but if they started from the right (shown in the blue rectangle) they were given (2). For the eye tracking part, if the first fixation was on the left image it was coded (1), on the center it was coded (2) and if it was on the right it was coded (3).

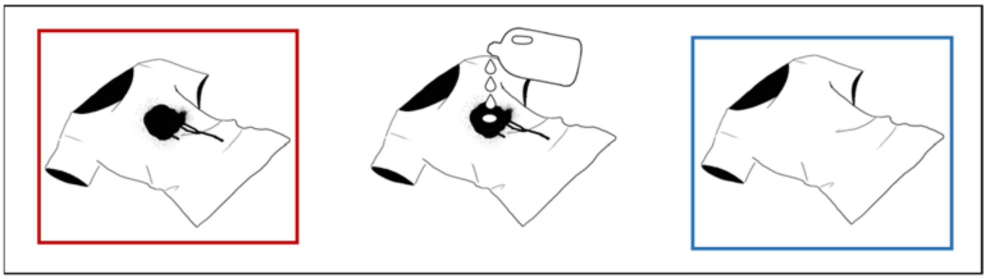

Figure 4. Regions of Sequence Task

Learning. The post-test questions (Appendix I) reflected the participants' learning. There were ten content-based questions that came after the sentence forming section. The questions covered the material presented in the instructional unit. These were multiple-choice questions to measure the participants' learning. Two questions from each of the instructional unit's five screen were constructed. Each correct answer was given a (1), and each incorrect answer was given a (0). The total score was a sum of the correct answers.

Visual fixation. The first period of stability of a person's eye on a point of interest. Figure 6 presents text vs. picture indicated by the eye-tracking device and was coded as (1) for text (shown in the red rectangle) or (2) for picture (shown in the blue rectangle). Afterwards for fixation on the parts of picture (Figure 7), giving left (shown in the red rectangle) a code (1), center (shown in the green rectangle) a code (2) and right (shown in the blue rectangle) a code (3).

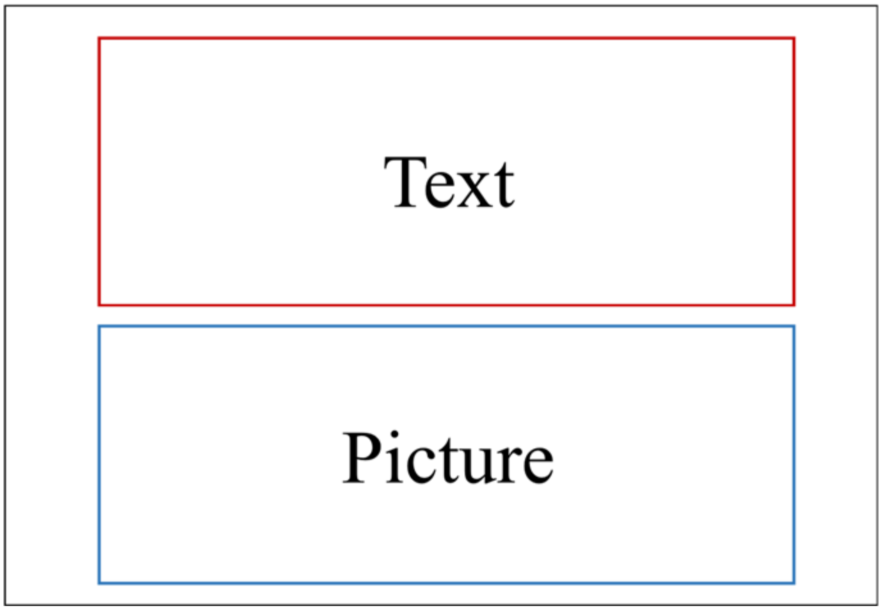

Figure 5. Regions of Visual Fixation (Text vs. Picture)

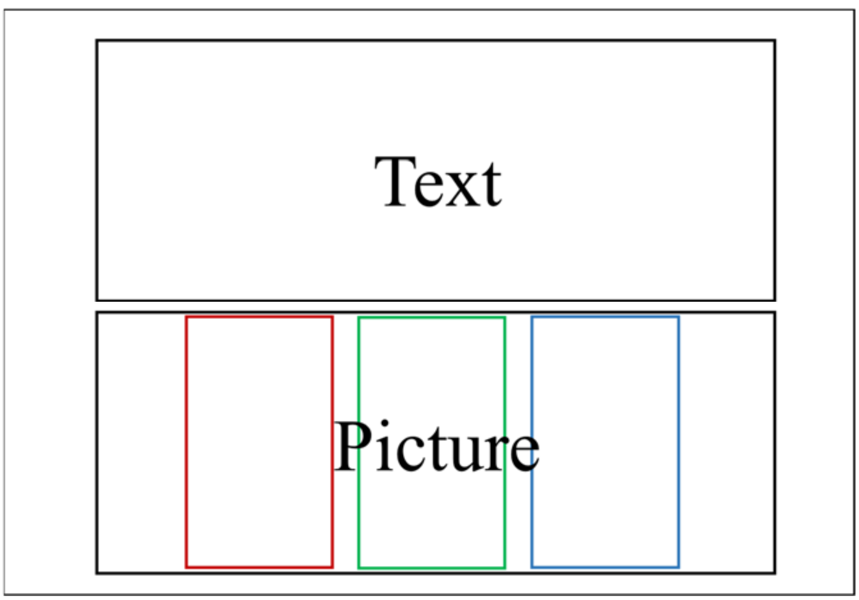

Figure 6. Regions of Visual Fixation (on Picture)

Mental effort. The mental effort rating test (Appendix E) used in the study was developed by Pass and the reliability of the scale was estimated by Cronbach's coefficient alpha (Pass, 1992). After each paragraph in the instructional unit, the learner was presented with a mental-effort rating question "How would you rate your mental effort after reading this material?" The mental effort test measures the learner's perceived cognitive load by using a 9-point scale ranging from 1 "very, very low mental effort" to 9 "very, very high mental effort" while participants work on the task.

Instructional Treatment

The instructional material covered the states of matter and the six phases: melting, freezing, vaporization, condensation, sublimation and deposition, a sample is shown in (Appendix D). The (NativeLeft_InstrEng), (NativeLeft_LrnRight_InstrEng) and (NativeRight_InstrEng) groups received the instructional material in English. The instructional material was translated and written in Arabic for the (NativeRight_InstrAra) group. The entire material was translated by a translator from English to Arabic and was retranslated from Arabic back to English by Google Translator to ensure accuracy of translation.

Images explaining the states of matter were created by the researcher. The images were a sequence of steps that can be logical if read in one direction only. Reading it from the reverse direction will provide the wrong instructional message. Images were arranged from left to right for the English written material. However, images were arranged from right to left for the Arabic written material. The instructional material was divided to five screens; two screens consisted of text only and three screens consisted of text with a center-aligned image under the text. Images were placed near the text to avoid split attention (Mayer, 2009). The instructional unit did not include a screen with images only.

Eye Tracker

To be compatible with the available eye-tracking device, this study focused on instructional material presented on a computer screen. In total, three computers were needed to carry out the treatment. Smart Eye tracking system software was installed and running on the first computer screen (Figure 8). It was connected to the third computer to calibrate and track the participant's gaze before recording. Video Streamer and Record Manager were also software used to record and save each session on the second computer screen (Figure 9). Participants were seated in front of a computer screen where they could complete the experiment (Figure 10). A remote 3D eye tracking system was installed on it. The system can include up to 8 cameras applied to a single screen. However, only three cameras were mounted on the participant's computer monitor, one on the top and two on the bottom. Output data, blinks, fixations and saccades were available in real time. The system is compatible with glasses, sunglasses and contact lenses. Reliability in eye tracking can only be measured within one specific experiment and validity can be measured by correlating the proposed measure with a valid criterion measure (Holmqvist et al., 2011).

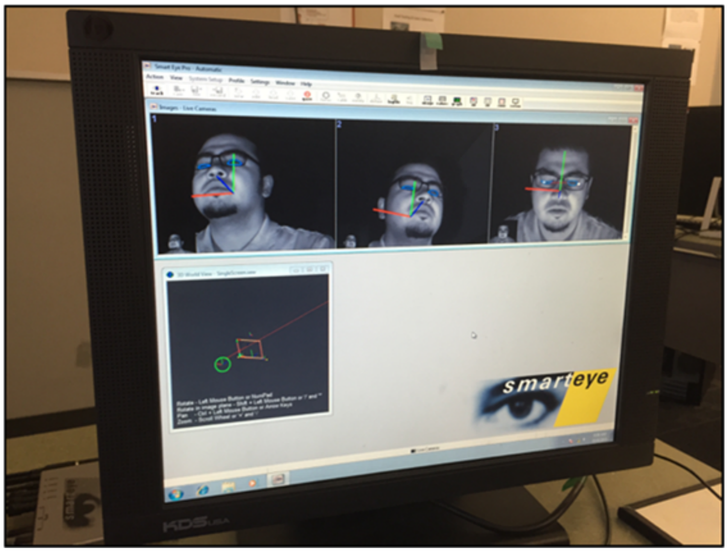

Figure 7. Smart Eye Pro (Computer Screen 1)

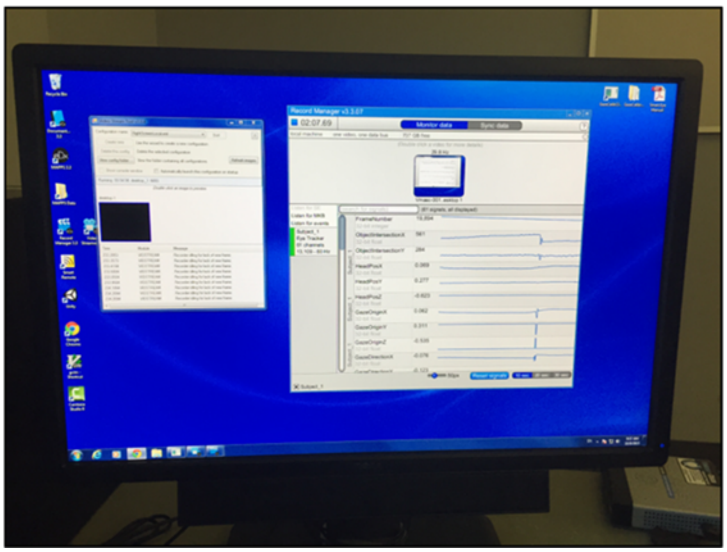

Figure 8. Recording Video (Computer Screen 2)

Figure 9. Participant's Experiment (Computer Screen 3)

Procedure

A computer-based survey program (Question Pro) was used to deliver the treatment and allowed for saving of the data. The study received IRB approval before collecting data. Participants received an email with a link to schedule an appointment with the researcher to participate in the study using eye tracking, since the eye-tracking device can only be used one by one. Participants who agreed on participating in the eye tracking study completed the survey on campus in a computer lab. Appointments were scheduled for over three months and email reminders were sent to the groups encouraging them to participate. The goal was to get as many participants as possible.

Eye tracking allowed for gathering real-time data. The researcher accompanied the participants while completing the experiment to record data. The experiment was simply based on answering questions (mostly multiple choice) through a survey link. Time allotted for the experiment was around 20-30 minutes. As an incentive, a twenty-dollar Amazon gift card was provided to each participant who completed the study on campus.

Each participant was granted an informed consent (Appendix A) before starting the experiment. The experiment consisted of one survey with eight sections: 1) demographic questions (Appendix B) where participants were asked to answer some general demographic questions such as age, gender, education degree, etc., 2) a pre-survey which is a self-estimate rating for prior knowledge (Appendix C) consisting eight domain-related 6-point scale rating items rating from 0 "none" to 5 "very much", 3) the instructional unit, 4) mental effort rating, 5) sentence forming questions, 6) recalling questions, 7) sequence question and finally 8) post-test questions. At the end of the survey, participants could enter their email in a separate survey to receive their Amazon gift card electronically.

Analysis

All data was collected and saved from a secured site and analyzed using SPSS. A one-way analysis of variance ANOVA was applied for each research question (Appendix J). The independent variable is the groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng). Table 2 presents the research questions and corresponding dependent variables and values. All tests included check of assumptions underlying one-way ANOVA.

Table 2

Variables and Research Questions Analysis

#	Research Questions	Dependent Variable	Value
1	Does a person's native language text orientation influence spatial bias?	Spatial Bias	*Sentence Forming Task* *Written & Eye Tracking* 1= Left 2= Right *Recalling Task* *Written*: 1= Left, 2= Both Sides, 3= Right *Eye Tracking*: 1= Left, 2= Right *Sequence Task* *Written*: 1= Left, 2= Right *Eye Tracking*: 1= Left, 2= Middle, 3= Right
2	To what extent does native language text orientation influence learner's first visual fixation on the material presented text versus pictures on screen?	Visual Fixation (text, picture)	1= Text 2= Picture
3	To what extent does native language text orientation influence the way learner's visual fixation varies for pictures on screen?	Visual Fixation (left, right)	1= Left 2= Middle 3= Right
4	To what extent does native language text orientation influence the learning of content?	Learning (post-test questions)	0= Incorrect answer 1= Correct answer
5	To what extent does native language text orientation influence mental effort for learners with different spatial orientations?	Mental Effort	1=Very very low mental effort 2= Very low mental effort 3= Low mental effort 4= Rather low mental effort 5= Neither low nor high mental effort 6= Rather high mental effort 7= High mental effort 8= Very high mental effort 9=Very very high mental effort

CHAPTER IV

RESULTS

This research was intended to help instructional designers determine whether to consider the arrangement of multimedia when designing instruction for individuals speaking a language with different text orientation, such as Arabic. Results are presented here for each research question.

Spatial Bias

For the first research question: *Does the person's native language text orientation influence spatial bias?* This question was answered by three tasks: sentence forming task, recalling task, and sequence task. For the first task, a one-way analysis of variance (ANOVA) was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variables (Avg_Written_Sentences and Avg_ET_Sentences), to evaluate the relationship between participants' spatial bias (written responses and their first fixation on the screen). Significance was found in written responses F (3,80) = 27.115, p=0.000, η^2= 0.504 and in first fixation eye tracking F (3, 80) = 14.461, p=0.000, η^2= 0.352. Figure 11 shows the mean differences among the groups comparing their written responses (in red) and first fixation on screen (in blue) measured by the eye tracking. Generally, this may indicate that participants were influenced by their native language's writing orientation.

According to the Tukey post-hoc test there was significant differences in the written responses part for the groups NativeLeft_InstrEng and NativeRight_InstrAra (M= 0.614, p = 0.000), NativeLeft_InstrEng and NativeRight_InstrEng (M= 0.256, p = 0.006), NativeLeft_LrnRight_InstrEng and NativeRight_InstrAra (*M*= 0.550, *p* = 0.000), NativeRight_InstrEng and NativeRight_InstrAra (*M*= 0.358, *p* = 0.000).

On the other hand, for the eye tracking part, there was significance in NativeLeft_InstrEng and NativeRight_InstrAra (*M*= 0.697, *p* = 0.000), NativeLeft_LrnRight_InstrEng and NativeRight_InstrAra (*M*= 0.700, *p* =0.000), NativeRight_InstrEng and NativeRight_InstrAra (*M*= 0.627, *p* = 0.000).

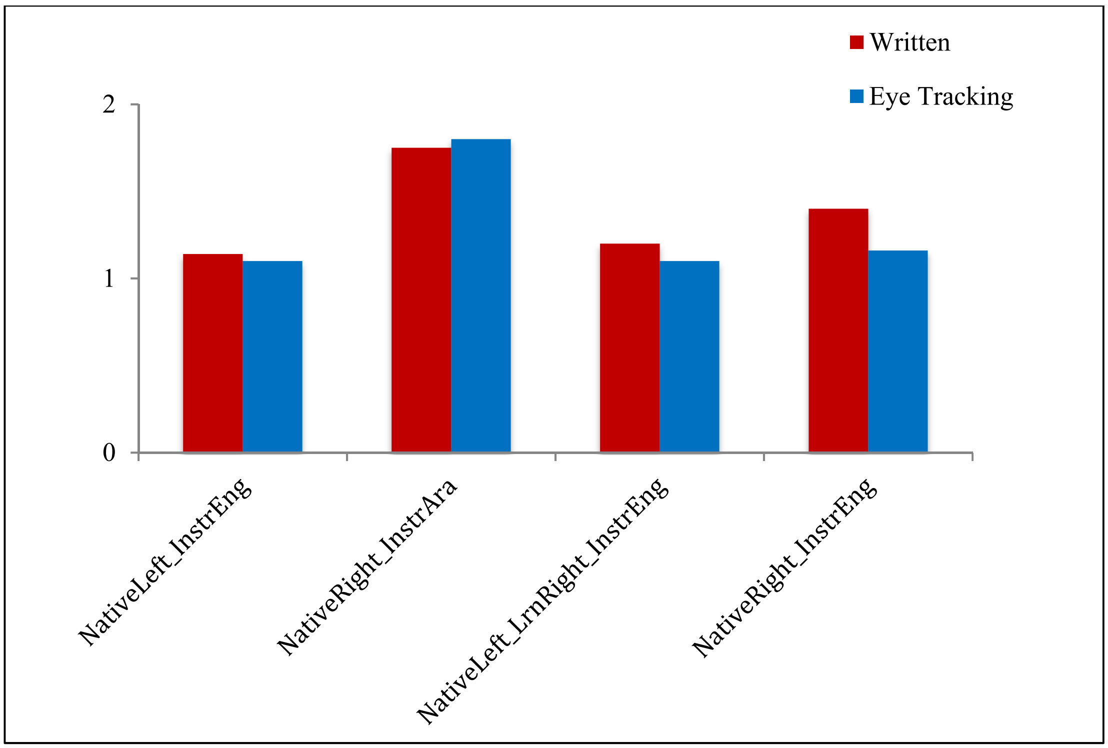

Figure 10. Sentence Forming Task (Written vs. Eye Tracking)

For the second task, there were two parts: recalling from the Screen of Words and recalling from the Screen of Images. A one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and dependent variables, the spatial bias of Screen of Words (Written_Words) and (ET_Words) to evaluate the relationship between participants' written responses and their fixation on words on screen. Then another one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and dependent variables, the spatial bias of Screen of Images (Written_Images) and (ET_Images) to evaluate the relationship between participants' written responses and their fixation on images on screen. Significance was found between groups F (3, 80) = 5.310, p = 0.002, η^2= 0.166 for the Word recall written part and F (3, 80) = 8.678, p = 0.000, η^2= 0.246 for the Words eye tracking part. Figure 12 presents the means of the recalled written words for each group and Figure 13 shows the means of fixations on words.

According to the Tukey post-hoc test, the significance was only between NativeRight_InstrAra and NativeLeft_LrnRight_InstrEng (*M*= 1.000, p = 0.001) for the Word written part. However, for the Word eye tracking part it was between NativeLeft_InstrEng and NativeRight_InstrAra (*M*= 0.676, p = 0.000),

NativeLeft_LrnRight_InstrEng and NativeRight_InstrAra (*M*= 0.650, p = 0.000).

However, significance was only found in the Image eye tracking part F (3, 80) = 20.609, p = 0.000, η^2= 0.436. Figure 14 shows the means of fixations on images. Significant differences for the eye tracking Image part were between NativeLeft_InstrEng and NativeRight_InstrAra (*M*= 0.739, p = 0.000), NativeLeft_LrnRight_InstrEng and NativeRight_InstrAra (*M*= 0.800, p = 0.000), NativeRight_InstrEng and NativeRight_InstrAra (*M*= 0.909, p = 0.000).

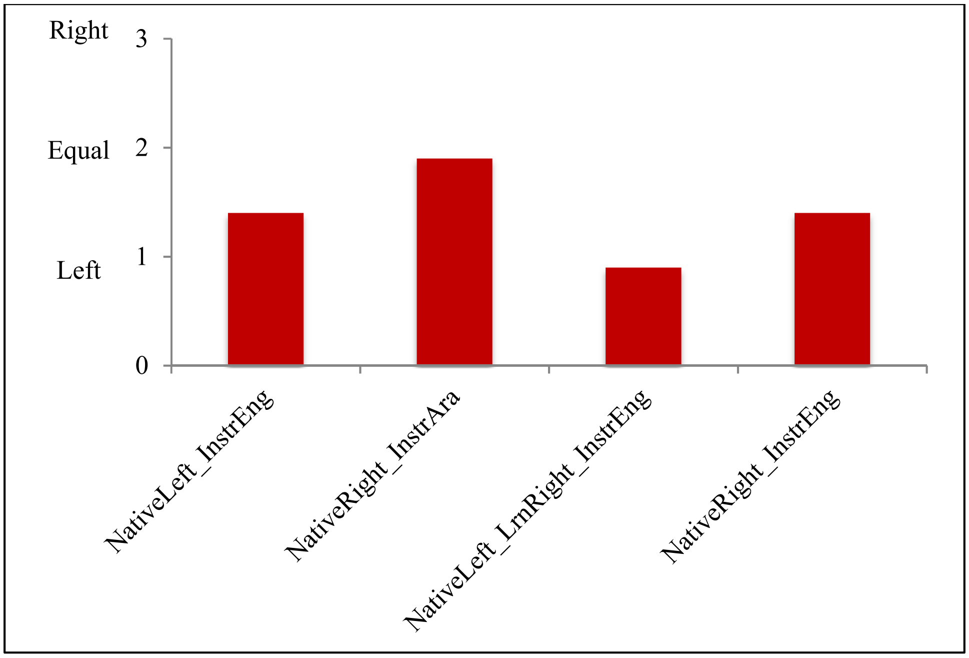

Figure 11. Word Recall Task (Written)

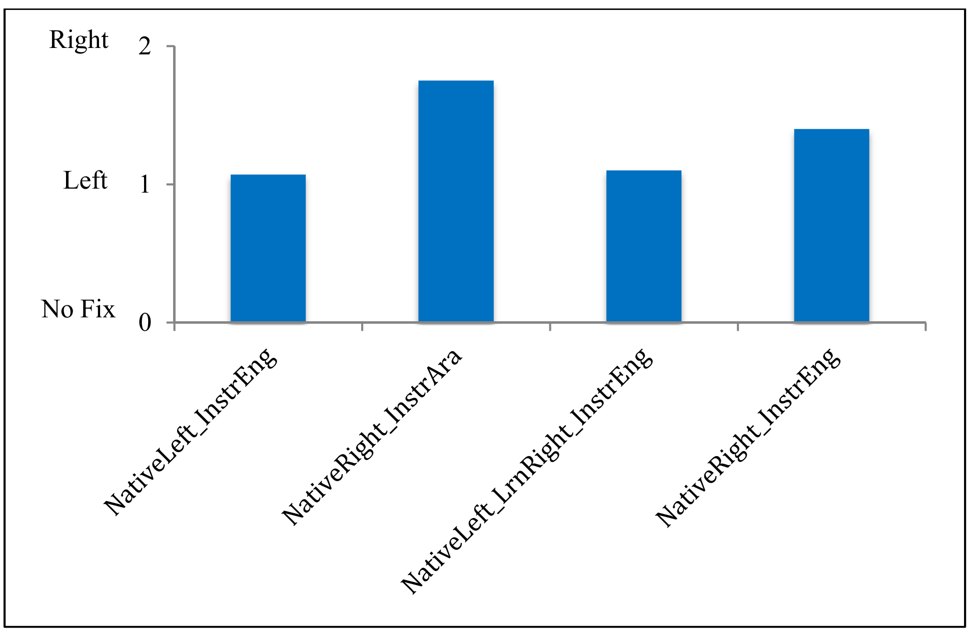

Figure 12. Word Recall Task (Eye Tracking)

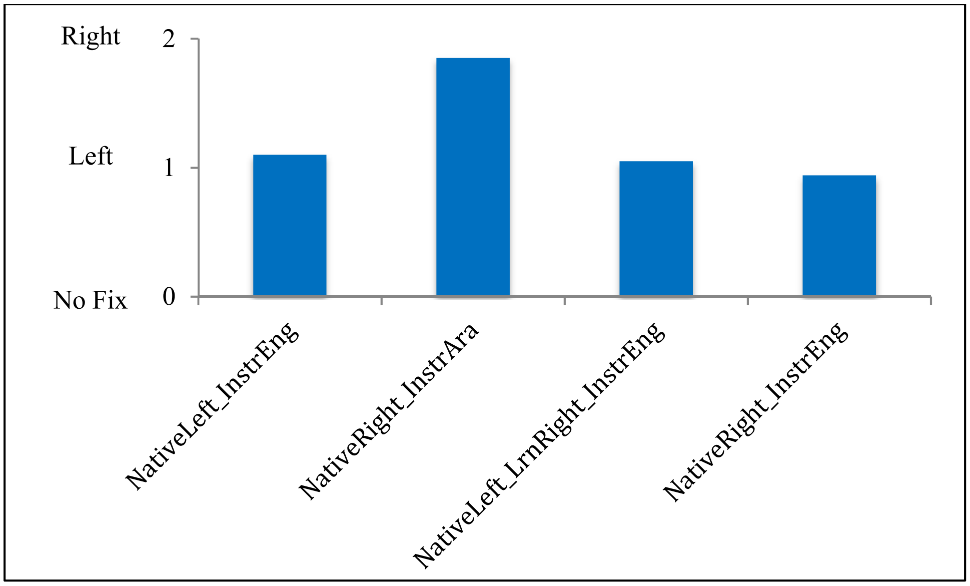

Figure 13. Image Recall Task (Eye Tracking)

For the third task or the sequence task, a one-way ANOVA was also performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and dependent variables, (Written_Sequence) and (ET_Sequence). Significance was only found in the eye tracking according to fixations F (3, 80) = 19.565, p = 0.000, η^2= 0.423. Figure 15 shows the means in eye tracking between the groups. According to the Tukey post-hoc test, significant differences were found between NativeLeft_InstrEng and NativeRight_InstrAra (M= 1.256, p = 0.000), NativeLeft_LrnRight_InstrEng and NativeRight_InstrAra (M= 1.400, p = 0.000), NativeRight_InstrEng and NativeRight_InstrAra (M= 0.877, p = 0.001).

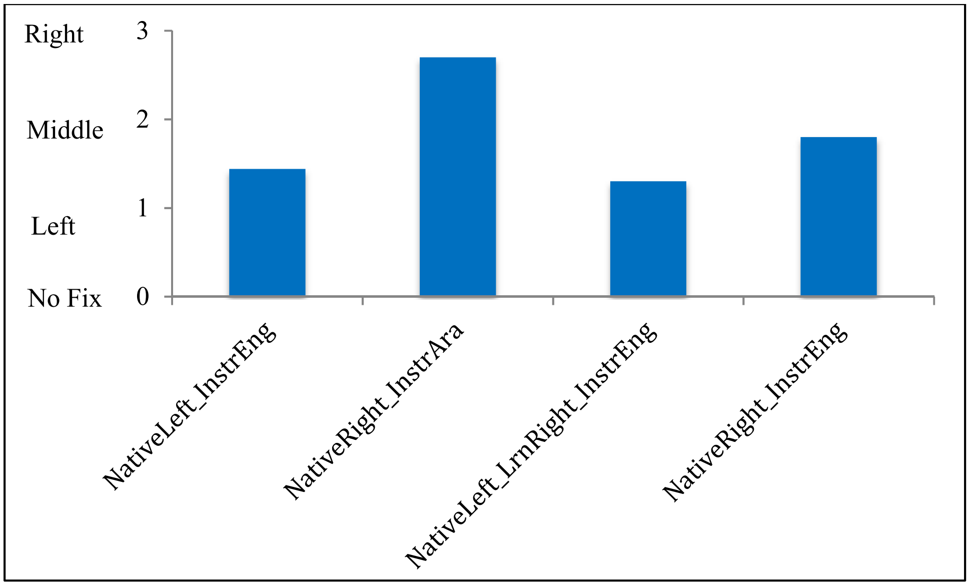

Figure 14. Sequence Task (Eye Tracking)

The means of each of the three spatial bias tasks are presented in Table 3. Each task was measured by written responses with eye fixations to compare if what participants see is what they write or recall.

Table 3

Spatial Bias Tasks Analysis

		Tasks (means)							
		Sentence		Word Recall		Image Recall		Sequence	
Group	*n*	Written	ET	Written	ET	Written	ET	Written	ET
NativeLeft_InstrEng	27	1.136	1.086	1.445	1.074	1.815	1.111	1.000	1.444
NativeRight_InstrAra	20	1.750	1.783	1.900	1.750	1.550	1.850	0.900	2.700
NativeLeft_LrnRight_InstrEng	20	1.200	1.083	0.900	1.100	1.150	1.050	1.000	1.300
NativeRight_InstrEng	17	1.392	1.157	1.412	1.353	1.706	0.941	1.000	1.824

First Visual Fixation on Screen

The second research question: *To what extent does native language text orientation influence learner's first visual fixation on the material presented, text versus pictures, on screen?* A one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variable, average first fixation on either text or picture on the three screens (Avg_Fix_Text_Pic), to find out if participants look at the text first or the picture when presented together on the screen but no significance was found F (3, 80) = 0.741, p = 0.531.

First Visual Fixation on Pictures

The third research question: *To what extent does native language text orientation influence the way learner's visual fixation varies for pictures on a screen?* A one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variable, average first fixation on pictures in a sequence –left, right or middle (Avg_Fix_PicDirection). No significance was found F (3, 80) = 1.950, p = 0.128, however, in learners' tendencies to fixate on pictures on the left, right, or center of the display. Generally according to the results presented in Table 4, participants' attention in all groups was focused on text before pictures and all had left visual fixation on the pictures as shown by their means.

Table 4

Visual Fixation Analysis

		Visual Fixation (means)	
		Average First Visual Fixation on Screen	Average Visual Fixation on Pictures
Group	*n*	Text vs. Picture	Right vs. Left
NativeLeft_InstrEng	27	1.148	0.728
NativeRight_InstrAra	20	1.050	0.950
NativeLeft_LrnRight_InstrEng	20	1.050	0.483
NativeRight_InstrEng	17	1.078	0.804

Learning of Content

The fourth research question: *To what extent does native language text orientation influence the learning of content?* For learning, pre-survey and post-test results with a covariate (pre-survey) were analyzed and compared. A one-way ANOVA was performed for the pre-survey self-estimate prior knowledge for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variable (pre-survey). Significance was found F (3,80) = 3.673, p= 0.016, η^2= 0.121 between NativeRight_InstrAra and the two groups NativeLeft_LrnRight_InstrEng (M= 0.9625, p= 0.037), NativeRight_InstrEng (M= 0.9716, p= 0.047).

A one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variable, learning (TotalScore) with covariate (pre-survey). Significance was found F (1,79) = 16.119, p= 0.000, η^2= 0.169 between the NativeRight_InstrAra group and three other groups NativeLeft_InstrEng (M= 0.332, p= 0.000), NativeLeft_LrnRight_InstrEng (M= 0.369, p=0.000), and NativeRight_InstrEng (M= 0.384, *p*=0.000). Figure 16 shows the means of the total scores on the post-test for all groups revealing NativeRight_InstrEng having the highest total score among all groups. Table 5 presents the average pre-survey with the total post-test scores for each group.

Cronbach's alpha was calculated for both pre-survey (α =0.937) and post-test (α = 0.435). Pre-survey was high but with some limitations. "Neutral" was one of the choices that participants used in the self-estimate rating which can be confusing for measuring prior knowledge. For post-test, the Cronbach's alpha was low due to having only ten multiple choice items which was not a lot of variability so it resulted in less reliability. Increasing the number of items will help sample the content knowledge.

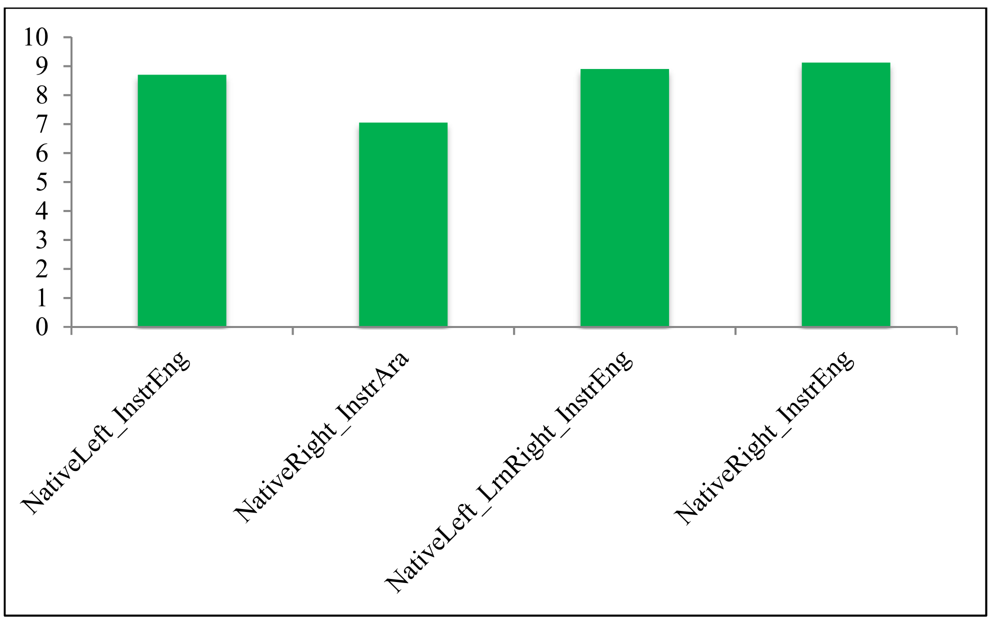

Figure 15. Total Post-Test Score

Table 5

Learning Analysis

		Learning (means)			
		Prior Knowledge		Learning	
Group	*n*	Average Pre-Survey		Total Post-Test Score	
		M	*SD*	*M*	*SD*
NativeLeft_InstrEng	27	3.477	1.251	8.667	1.000
NativeRight_InstrAra	20	3.131	1.456	7.050	1.504
NativeLeft_LrnRight_InstrEng	20	4.094	0.777	8.900	1.294
NativeRight_InstrEng	17	4.103	0.163	9.118	1.054

Note: Scores range from 0 to 5 for prior knowledge pre-survey and from 0 to 10 for posttest.

Mental Effort

The fifth research question: *To what extent does native language text orientation influence mental effort for learners with different spatial orientations?* A one-way ANOVA was performed for the independent variable groups (NativeLeft_InstrEng, NativeRight_InstrAra, NativeLeft_LrnRight_InstrEng, NativeRight_InstrEng) and the dependent variable, mental effort, for each section. There were five sections in the instructional material and the mental effort question was asked after each section. The analysis was performed for each section individually. However, no significance was found in any of the five mental effort questions F (3, 80) = 0.741, p = 0.531. Table 6 presents the means of each mental effort question for each group. Each question was on a 9-point scale ranging from 1 "very, very low mental effort" to 9 "very, very high mental effort"

Table 6

Mental Effort Analysis

		Mental Effort (means)				
Group	*n*	ME1	ME2	ME3	ME4	ME5
NativeLeft_InstrEng	27	4.074	4.222	3.704	4.222	4.444
NativeRight_InstrAra	20	4.300	4.350	3.450	3.500	4.200
NativeLeft_LrnRight_InstrEng	20	3.950	4.100	3.700	3.800	4.400
NativeRight_InstrEng	17	3.529	3.824	3.000	3.412	3.765

Summary

The study explored the influence of a language's written orientation on five variables: spatial bias, visual attention on text versus pictures, visual attention on pictures, learning and mental effort. In conclusion significance was found in spatial bias and learning. Spatial bias was measured by three tasks, two of the three tasks were significant. On the other hand, no significance was found in visual attention on text versus pictures, visual attention on pictures and mental effort. After presenting the results of the study, discussion and conclusions will be mentioned in the upcoming chapter. Relating the results with literature will be presented.

CHAPTER V

DISCUSSION AND CONCLUSIONS

Analysis of the results supports that language orientation has an impact on an individual's spatial bias. Two out of the three tasks used to test the first research question support this conclusion. The sentence-forming task presented three pairs of black/white images and asked participants to write a sentence without any connecters (and/ or) using the pair of pictures. If the participant chose the image on the left as the subject for the sentence, that indicated left bias and vice versa (Chan & Bergen, 2005). The eye tracker was also used to indicate whether the first fixation was on the left image or the right image. Results were then compared with the written portion of the task. The image chosen by the learner as the subject for their written sentence correlated to what eye tracking recorded as the first fixation. This indicates that the image the participant sees first is the one he/she chooses for the sentence subject. The groups NativeLeft_InstrEng and NativeLeft_LrnRight_InstrEng all showed left bias. However, the group NativeRight_InstrAra showed right bias. These results confirmed Chan and Bergen (2005) findings that native language significantly affects sentence orientation. However, although the group NativeRight_InstrEng is native right oriented they showed left bias, but their mean was slightly heading toward a right bias. This group, in particular, might have been influenced by the text direction of the language in which the instruction was written, which was English. In multimedia learning, viewing behavior is associated with text direction (Schmidt-Weigand et al., 2010).

Similar results were observed in the recalling task. Participants were asked to recall at least three of the sixteen words displayed on the Screen of Words and then list at least three images from the Screen of Images. The words and images were tallied to determine from which side the participant recalled the most. In both cases, eye tracking was used to check their first fixation side, left or right. In recalling written words, the groups NativeLeft_InstrEng, NativeLeft_LrnRight_InstrEng and NativeRight_InstrEng all showed left bias, but the group NativeRight_InstrAra recalled equally from both sides. On the other hand, written images showed no significance at all. Usually during retention, pictures are remembered better than words (Jonassen, 1982). Regarding eye tracking for words and images, the groups NativeLeft_InstrEng, NativeLeft_LrnRight_InstrEng and NativeRight_InstrEng all showed left bias, but the group NativeRight_InstrAra showed right bias. These results are consistent with those from the first task. Although Chan and Bergen (2005) only performed an image recall task on English, Chinese and Taiwanese participants, results from this study were consistent with Chan and Bergen's results which showed that writing direction has an impact on spatial characteristics of visual attention. The same conclusion can explain the NativeRight_InstrEng group having a left bias.

For the sequence task, participants were presented with three related black/white images placed horizontally. They were asked to explain the sequence in the pictures. The images can be explained differently depending on the direction of the sequence in which they are viewed. There was no significance in the written part since all but four participants in all groups explained the pictures from left to right. The four exceptions, who started from the right, were all part of the NativeRight_InstrAra group. This supports Mass and Russo (2003) finding that right bias will be lower for Arabs living outside their home country. Also since all participants are in a university environment they are exposed to English which might have affected their explanation in the sequence task. Eye tracking, however, revealed that the first fixation for NativeLeft_InstrEng and NativeLeft_LrnRight_InstrEng group members was on the left image. NativeRight_InstrAra group members focused on the right image and NativeRight_InstrEng group members focused on the middle image.

Overall, the results support that language writing orientation influences spatial bias. Furthermore, if instructions were presented in a different language of a person's native language, it can affect the bias as was seen in the NativeRight_InstrEng group. Chan and Bergen (2005) presented all instructions orally, in the participant's native language, to avoid the influence of the language orientation on participants.

It is difficult to measure learners' attention to multimedia on the screen, however by using eye tracking technology, it is possible to analyze learners' interaction (Chuang & Liu, 2012). Eye tracking was used to measure the second research question and no written responses were involved. Analysis was based on three screens of instructional material that consisted of text and pictures. The eye tracker was used to determine if first fixation was on the text or on the picture. Tracking eye movements can provide a blueprint on how information was processed and retrieved (Chuang & Liu, 2012). This can help to indicate how learners process information visually and cognitively. No significance was found. Participants looked at text first, several did not even glance at the picture. This might be explained that learners usually spend more time reading text than checking the visuals when text is written than spoken (Schmidt-Weigand et al., 2010). In addition, not examining the picture can be due to the difficulty of relating the picture with the text; in this case the picture becomes a distraction reducing instructional value (Jonassen, 1985). In this study, the picture would be considered redundant information used only to simplify what was explained in the text. However, there was no reference to the picture in the text. Learners might read first then look at the picture, look at the picture every time a component is referred to in the text, or read a portion of text and then verify understanding using the image presented (Van Gog & Scheiter, 2010). Thus, since no components were mentioned in the text, participants simply ignored the image. Learners would process images if they were relevant to the text (Chuang& Liu, 2012). Directing learners to pictures in text can have effective outcomes. Also, the difficulties in directing attention can be avoided by choosing where to place pictures on the screen (Jonassen, 1982).

Another factor that might affect attention is expertise. This finding would be consistent with the argument that expert learners learn to ignore redundant information and that was probably what caused participants to ignore the picture presented on the screen (Van Gog & Scheiter, 2010).

The third research question was like the concept of the second question, but the task was designed to determine whether the first fixation on images presented was on the right, middle or left image. No significance was found since pictures were not visually appealing. Pictures can be more effective in instructional material, however, it is not always easy to understand the effectiveness of pictures, as some learners might not look at pictures and some might look, but not comprehend the image (Jonassen, 1982). Perhaps the lack of significant differences between groups in the second and third research questions is due to the pictures presented. Chaung & Lui (2012) observed different eye tracking results when text and pictures were displayed in the presentation. In their study, participants were more engaged in processing pictures than text. In this study, however, pictures were not particularly attractive, being black/white with no labels or arrows. According to Jonassen (1982), figures and diagrams should have arrows and lines between concepts to show process direction. In addition, follow up questions can be used to direct attention to pictures and other material not mentioned in the text. In contrast, black elements on a white background are powerful for manipulating attention and that color may not improve performance (Szlichcinski, 1979).

The fourth research question focused on what was learned from the instructional material. The participants were presented with ten multiple-choice questions after wiping their short-term memory with other tasks. Each participant received a total score depending on the number of correct answers. The NativeRight_InstrEng (*M*= 9.118) performed the best in learning. On the other hand, NativeRight_InstrAra (*M*= 7.050) performed the worst among the groups. The challenges of being bilingual and answering in your second language might have a positive effect on learning outcomes such as seen in NativeRight_InstrEng group. Although the group NativeRight_InstrEng native language is written from right to left,18% of the participants' home country is the US. That might have affected the results by having left bias for that group.

The last research question focused on mental effort and prompted learners to gauge their mental effort after being presented with each of the five instructional screens. Participants had to rate their mental effort in a 9-point scale. There was no significance since all ratings ranged from 3 (low mental effort) to 4 (rather low mental effort). The topic of the material, states of matter, is often commonly understood and taught before. The simplicity of the instructional material might have influenced results. Each screen had two paragraphs each consisted of four sentences, which were not difficult to comprehend. The paragraphs that did not overload working memory, making it simple to transfer to long term memory, and therefore easy to retrieve not causing any mental effort.

Limitations

A culture issue arises in selecting the groups for this study. It should be noted that a group of native Arabic speakers that never experienced a language with left to right orientation was not included in the study. This is due to the difficulty of finding a group that knows Arabic, but does not know English. English is taught as a second language in schools in most Arab countries. Elderly people may not have learned English in schools, but most know how to speak the language although they may not know how to write it. In addition, there were more female participants due to some cultural challenges especially with NativeRight_InstrAra. Based on the culture of their home country, it is preferred that limited interaction exists between male and female. Since the researcher is a female from the same home country, most the participants that were willing to participate were females per tradition.

Next, for more accurate results when using the eye tracker, positioning the individual in front of the screen is important. Participants were aware of the eye tracking instructions before starting the survey and were sitting in a position that allowed the eye tracker to record accurately. However, some participants did move, scratch their nose or even drank coffee. These simple movements may have affected some results.

All participants were recruited from the university, so all were experienced learners to reading and answering questions. Results might have been different with participants not in an educational environment.

Finally, another important aspect that was not taken into consideration was NativeLeft_LrnRight_InstrEng participants' level of fluency in the Arabic language they had learned or were in the process of learning. Most were at a beginner level, which made it difficult to consider whether this impacted bias. It also made it difficult to compare them to the native right speakers since these individuals were more fluent in English having studied it from an early age.

Future Research

Future research on this topic could explore a variety of other aspects that would be beneficial to instructional designers dealing with other languages and cultures. Extending to this study, tracking eye movements on screens with images only without text can be considered. In addition to investigating first visual fixation, the number of fixations and time spent can be considered for supporting conclusions. The use of eye tracking could also test students' eye fixations on other media such as 3D images and animations (Chuang & Liu, 2012). English speakers tend to prefer images that involve motion from left to right (Maass & Russo, 2003), but what about other languages preference and how might it affect learning. This will help developers, designers and instructors to whether to consider language when designing moving objects or integrating it in learning. It would be interesting to examine the results when students are presented with two languages with the same orientation such as English and Spanish. It would also be interesting to include languages oriented from top to bottom, such as Japanese, and test learners' visual attention, bias and learning. Another future study would be doing a time-series study comparing novices to experts using the eye tracker.

Image placement has traditionally been based on aesthetic decisions rather than instructional (Jonassen, 1982), but unfortunately no studies explored the arrangement of images such as above or to the left or right of the text and how it affects learning outcomes according to different languages.

Conclusion

To conclude, this study was intended to help instructional designers arrange and design material for multi-language audiences according to how they encode the instructional material. Placement of text and pictures is determined by how the designers want to direct the learner's attention (Alessi & Tollip, 2001). According to the spatial contiguity principle it is preferred to place the pictures near the text to avoid split attention (Mayer, 2009). Usually, pictures are placed above or below paragraphs, however, if left unchanged these patterns can lead to a learner's lack of interest (Jonassen, 1982). According to the spatial contiguity principle, better learning will be achieved if pictures were placed near the text (Mayer, 2009). For effective learning, it is better to place the most important instruction where the learner's attention is focused, according to their orientation bias. Generally, a simple and well-designed instruction will be more effective for international users (Kearsley, 1990). Designers need to be familiar with international users' languages and cultures from the beginning to avoid any misunderstanding. Pictures should be designed to improve student comprehension (Jonassen, 1982) and add value to the learning material. Learning environments involving graphics should be designed to accommodate how people learn and think (Mayer, 2010). However, exposure to other languages, culture, or beliefs, or living for a time in a country that speaks a language with a different text orientation can influence learner's spatial bias as seen with the NativeRight_InstrEng group.

NativeRight_InstrEng showed a weaker left bias than the group NativeLeft_InstrEng, however, the left bias might be attributed to their consistent exposure to English as the local language used in university classrooms. Location of attention and initial fixation is influenced by reading direction (Smith & Elias, 2013), which was English for their group. In addition, 23.5%

of the participants in the NativeRight_InstrEng group speak English in their everyday lives. On the other hand, only 10% of the participants in the NativeRight_InstrAra use English as the language spoken at home. This is likely another contributing factor to the group's strong right bias. The number of years the individual's eyes and hands move in a direction when reading and writing can have some effects outside the domain of reading and writing (Treiman & Allaith, 2013).

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Appendix A. Informed Consent

PROJECT TITLE: The Influence of Language on Multimedia: An Eye Tracking Study

INTRODUCTION

The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participation in this research regarding the influence of language on multimedia, an eye tracking study at Room 1116 in the Engineering & Computational Sciences Building (ECSB) at Old Dominion University and to record the consent of those who say YES.

RESEARCHERS

Ginger S. Watson, Ph.D., **Responsible Project Investigator**
Associate Professor
Instructional Design & Technology Program
Department of STEM Education and Professional Studies
Darden College of Education & Virginia Modeling, Analysis & Simulation Center
Old Dominion University

Arwa A. Mashat
Doctoral Candidate
Instructional Design and Technology Program
Department of STEM Education and Professional Studies
Darden College of Education
Old Dominion University

DESCRIPTION OF RESEARCH STUDY

If you decide to participate in this study, you will join a study involving eye tracking to track your eye movements. If you choose to participate in this study, you will complete an online survey that includes a short pre-test, a unit of instruction, and a post-test. This research will be looking into images with text and how the learners interact with the material presented. In addition, the study looks at the student's learning when material is presented in English versus presented in Arabic and if the writing orientation of a language has any affect on learning. Approximately 60 participants will complete this study. If you say YES, then your participation will last for approximately 45-60 minutes at the Engineering & Computational Sciences Building (ECSB), Old Dominion University.

EXCLUSIONARY CRITERIA

You should be 18 or older and ONE of the following:

- Native English speaker and never learned or experienced a language written from right to left.
- Native English speaker learning Arabic
- Native Arabic speaker

RISKS AND BENEFITS

RISKS: This study uses eye tracker to record your eye movements. The eye tracker does not involve any physical contact with you and your experience should be similar to using a desktop computer with keyboard and mouse. This type of eye tracker should not cause you physical discomfort.
BENEFITS: There are no direct benefits for participation in the study.

COSTS AND PAYMENTS
There will be no costs for participating in this study. The researchers want your decision about participating in this study to be absolutely voluntary. Yet they recognize that your participation may pose costs such as time and effort. In order to help defray your cost you will receive $20 gift card after completing the study.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
The researchers will take all steps necessary to keep private information confidential. The researcher will store information in a locked filling cabinet and personally identifiable information will be replace with an identification number prior to its processing by the research team. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you. Of course, your records may be subpoenaed by court order or inspected by government bodies with oversight authority.

WITHDRAWAL PRIVILEGE
It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the study -- at any time.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of injury or illness arising from this study, neither Old Dominion University nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in any research project, you may contact Dr. Ginger Watson, principal investigator, at 757-683-3246 or Dr. George Maihafer the current IRB chair at 757-683-4520 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460, who will be glad to review the matter with you.

VOLUNTARY CONSENT
By clicking on the “Yes, I agree” button below you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, then the researchers should be able to answer them: Ginger S. Watson, Ph.D. (757 – 683 – 3246) or Arwa Mashat (330 – 550 – 9348). If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. George Maihafer, the current

IRB chair, at 757-683-4520, or the Old Dominion University Office of Research, at 757-683-3460. And importantly, by clicking on the “Yes, I agree” button below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Appendix B. Demographic Questions

Please answer the following questions:

Q1- Are you male or female?

- Male
- Female

Q2- Which category below includes your age?

- 18-20
- 21-29
- 30-39
- 40-49
- 50-59
- 60 or older

Q 3- What is the highest level of school you have completed or the highest degree you have received?

- Less than high school degree
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor degree
- Graduate degree

Q4- Is the United States your home country?

- Yes, go to question 5
- No, go to question 6

Q5- If yes, where have you lived outside the United States?

- Yes, please specify ....
- No

Q6- If no, what is your home country? ....

Q7- How long have you lived outside the United States?

- Never
- Less than one year
- 2-5 years
- 5 + years

Q8- What age did you start learning English?

- Never Learned
- Birth- 5
- 6-10
- 11-20
- 21-30
- 31-40
- 41 and older

Q9- What language do you mainly speak at home?

- English
- Arabic
- Both Arabic and English
- Other, please specify............

Q10- Are you?

- Left-handed
- Right-handed
- Both

Q11- As you are responding to the questions,… are you wearing any?

- Glasses
- Contact Lenses
- None

Appendix C. Pre-Survey

How would you rate your knowledge about the following principles? Check under the number that applies.

Questions	0	1	2	3	4	5
	None	**Very Little**	**Little**	**Neutral**	**Much**	**Very Much**
1- I know the atoms that form a water molecule.						
2- I can list the different forms of matter.						
3- I know about *melting*.						
4- I know about *freezing*.						
5- I know about *vaporization*.						
6- I know about *condensation*.						
7- I know about *sublimation*.						
8- I know about *deposition*.						

Appendix D. Samples of the Instructional Unit

Screen without Image

Phase 1: Melting

Melting occurs when solids are changed to liquid due to heat. There is a special temperature for every substance called the melting point. When a solid reaches the temperature of its melting point, it can become a liquid. For ice to become water, the temperature needs to be a little over zero degrees Celsius for it to melt.

Phase 2: Freezing

Freezing occurs when liquid is changed to solid when the temperature is lowered below its freezing point. If you put a water drop in the freezer, it would become a solid piece of ice. No matter what physical state it is in, it is always water. It always had the same chemical properties.

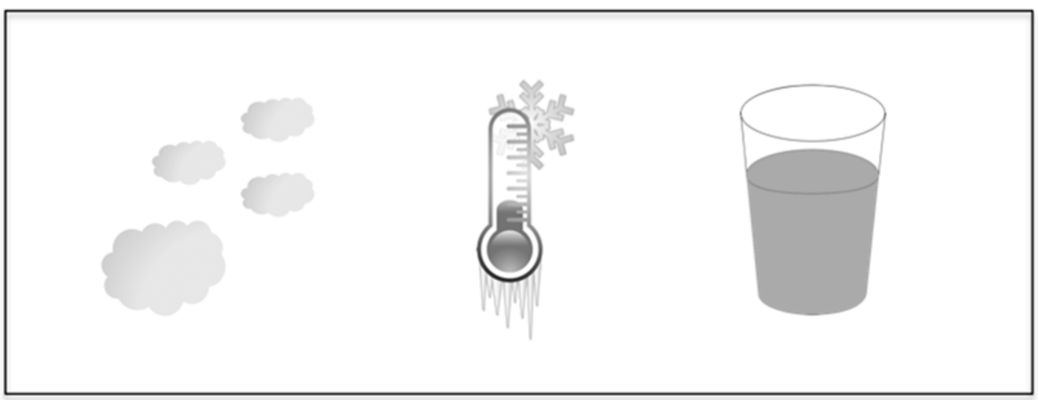
Screen with Image

Phase 3: Vaporization

Vaporization occurs when liquid is changed to gas at high temperatures. Once you can direct that energy into your molecules, they will start to vibrate. If they vibrate enough, they can escape the limitations of the liquid and become a gas. When you reach your boiling point, the molecules in your system have enough energy to become a gas.

Phase 4: Condensation

Condensation is the reverse of vaporization and happens when several gas molecules come together and form a liquid. Gases are really excited atoms. When they lose energy, they slow down and begin to collect into one drop. Water vapor in the form of steam condenses on the surface (lid of your pot) when you boil water.



Reference: Wonderopolis. Retrieved from http://wonderopolis.org/wonder/does-matter-really-matter

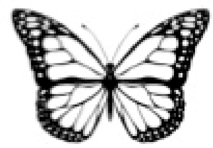
Appendix E. Mental Effort Rating

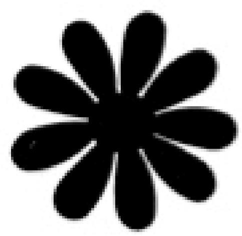
How would you rate your mental effort after reading the previous paragraph? *

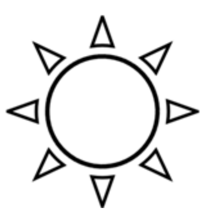
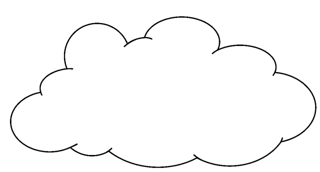
○ 1 very, very low mental effort	○ 2 very low mental effort	○ 3 low mental effort	○ 4 rather low mental effort	○ 5 neither low nor high mental effort	○ 6 rather high mental effort	○ 7 high mental effort	○ 8 very high mental effort	○ 9 very, very high mental effort

Appendix F. Sentence Forming Task

Write a sentence mentioning the two objects without using any conjunction (and, or, nor). It is preferred to use verbs to connect the two objects. The first object you see, use it as the subject.

Appendix G. Recalling Task

Screen of Words

ball	lion	rain	home
head	cake	eyes	rope
fish	hair	baby	salt
tree	name	star	cold

Screen of Images

Appendix H. Sequence Task

Appendix I. Post-Test Questions

1- Dry ice is an example of:

☐ Condensation

☒ Sublimation

☐ Deposition

2- Scientists received a Nobel Prize for working with:

☒ Bose-Einstein Condensate

☐ Albert Einstein

☐ Bernard Caesar Einstein

3-When water molecules reach the boiling point, they become:

☐ Liquid

☐ Solid

☒ Gas

4-Water molecular structure whether it is a gas, liquid, or solid has the same:

☐ Physical state

☒ Chemical state

☐ Temperature

5- The phase when water vapor turns to water drops is called:

☒ Condensation

☐ Sublimation

☐ Vaporization

6- Adding energy in a physical state means:

☐ Lowering temperature

☒ Increasing temperature

☐ Same Temperature

7-When liquids are changed to solids due to cold temperature is called:

☐ Sublimation

☒ Freezing

☐ Melting

8- Deposition is when:

☒ Gas becomes solid

☐ Solid becomes gas

☐ Liquid becomes solid

9-For ice to become water, the temperature needs to be:

☒ Over zero degrees Celsius

☐ Below zero degrees Celsius

☐ At zero degrees Celsius

10- Destroying the bonds between atoms in a molecule is considered a:

☐ Environmental change

☒ Chemical change

☐ Phase change

Appendix J. ANOVA Tables

Table
ANOVA Results for Spatial Bias Sentence Forming Task (Written)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.919	3	1.640	27.115	.000
Within Groups	4.838	80	.060		
Total	9.757	83			

Table
ANOVA Results for Spatial Bias Forming Task (Eye Tracking)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.093	3	2.364	14.461	.000
Within Groups	13.080	80	.164		
Total	20.173	83			

Table
ANOVA Results for Spatial Bias Recalling Words Task (Written)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.032	3	3.344	5.310	.002
Within Groups	50.384	80	.630		
Total	60.417	83			

Table
ANOVA Results for Spatial Bias Recalling Words Task (Eye Tracking)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.275	3	2.092	8.678	.000
Within Groups	19.284	80	.241		
Total	25.560	83			

Table
ANOVA Results for Spatial Bias Recalling Images Task (Written)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.468	3	1.823	2.646	.055
Within Groups	55.103	80	.689		
Total	60.571	83			

Table
ANOVA Results for Spatial Bias Recalling Images Task (Eye Tracking)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.130	3	3.377	20.609	.000
Within Groups	13.108	80	.164		
Total	23.238	83			

Table
ANOVA Results for Spatial Bias Sequence Task (Written)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.152	3	.051	1.069	.367
Within Groups	3.800	80	.048		
Total	3.952	83			

Table
ANOVA Results for Spatial Bias Sequence Task (Eye Tracking)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24.606	3	8.202	19.565	.000
Within Groups	33.537	80	.419		
Total	58.143	83			

Table
ANOVA Results for Visual Fixation (Text vs. Picture)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.157	3	.052	.741	.531
Within Groups	5.647	80	.071		
Total	5.804	83			

Table
ANOVA Results for Visual Fixation on Picture

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.272	3	.757	1.950	.128
Within Groups	31.077	80	.388		
Total	33.349	83			

Table
ANOVA Results for Average Pre-Survey

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.590	3	4.530	3.673	.016
Within Groups	98.676	80	1.233		
Total	112.265	83			

Table
ANOVA Results for Total Score (Post-Test) with Covariate (Pre-Survey)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31.920	3	10.640	8.540	.000
Within Groups	98.431	79	1.246		

Table
ANOVA Results for Mental Effort 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.751	3	1.917	.770	.514
Within Groups	199.237	80	2.490		
Total	204.988	83			

Table
ANOVA Results for Mental Effort 2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.798	3	.933	.440	.725
Within Groups	169.487	80	2.119		
Total	172.286	83			

Table
ANOVA Results for Mental Effort 3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.220	3	2.073	.707	.551
Within Groups	234.780	80	2.935		
Total	241.000	83			

Table
ANOVA Results for Mental Effort 4

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.159	3	3.053	1.147	.335
Within Groups	212.984	80	2.662		
Total	222.143	83			

Table
ANOVA Results for Mental Effort 5

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.513	3	1.838	.708	.550
Within Groups	207.725	80	2.597		
Total	213.238	83			

VITA

Arwa Abdulwahab Mashat
Instructional Design & Technology
Old Dominion University
4112 Education Building
Norfolk, VA 23529

EDUCATION

Doctor of Philosophy — Jan 2011 – May 2017

Instructional Design & Technology

Old Dominion University, Norfolk, Virginia, USA

Master of Science — Aug 2008 - Dec 2009

Education Technology

Youngstown State University, Youngstown, Ohio, USA

Bachelor of Science — Jan 2000 - June 2004

Computer Science

King Abdulaziz University, Jeddah, SA

EMPLOYMENT

Instructional Designer — Sep 2013- Jan 2014

Center for Learning and Teaching, Old Dominion University, Norfolk, VA

Computer Teacher — 2004 – 2008

The 12th Secondary School, Makkah, Saudi Arabia

AWARDS

Alan Mandell Endowed Award for Instructional Design & Technology for 2014-2015

College of Education, Old Dominion University

CONFERENCE PRESENTATIONS

Mashat, Arwa, Watson, Ginger S. (2016, October 17-21). *Measuring spatial bias with visual and written material using eye tracking*. Presentation given at the 2016 Association of Educational Communication and Technology International Convention, Las Vegas, NV.

Mashat, Arwa, Watson, Ginger S. (2016, April). *The Challenges of Translating Simulations from an Instructional Design View*. Presentation given at the 10th Annual Student Capstone Conference, Virginia Modeling Analysis and Simulation Center, Suffolk, VA.

Mashat, Arwa, Watson, Ginger S., Stefaniak, Jill & Pribesh, Shana. (2015, November 3-7). *The influence of language on multimedia design: An eye tracking study*. Presentation given at the 2015 Association of Educational Communication and Technology International Convention, Indianapolis, IN.

Mashat, Arwa, Watson, Ginger S., & Adcock, Amy. (2014, November 4-8). *The impact of spatial bias and language on designing multimedia presentations*. Presentation given at the 2014 Association of Educational Communication and Technology International Convention, Jacksonville, FL.

CERTIFICATES

- Modeling and Simulation in Education and Training May 2016
- Preparing Future Faculty, Old Dominion University Dec 2015
- Leadership Lecture Series, Old Dominion University Dec 2011