2016

Short Term Memory of Magnetic Resonance Imaging Technologists

Samuel Maldonado
Walden University

Walden University

College of Social and Behavioral Sciences

This is to certify that the doctoral dissertation by

Samuel Maldonado

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Stephen Burgess, Committee Chairperson, Psychology Faculty
Dr. Steven Linnville, Committee Member, Psychology Faculty
Dr. Abby Harris, University Reviewer, Psychology Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2016

Abstract

Short Term Memory of Magnetic Resonance Imaging Technologists

by

Samuel Maldonado

MS, Walden University, 2010

MS, Polytechnic University, 1996

BS, Herbert H. Lehman College, 1986

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Health Psychology

Walden University

May 2016

Abstract

This study examined the short-term memory (STM) difference of magnetic resonance imaging (MRI) technologists versus non-MRI technologists. Human and animal studies have indicated that residual magnetic fields have caused changes within the cerebral structure. Research on residual magnetic fields and their effect on STM are still at its infancy. A quasi-experimental design was used to determine if any significant difference existed between the STM of MRI technologists and a control population sample. The STM of both groups was assessed with the use of the Rivermead Behavioural Memory Test-Third Edition (RBMT-3). Solicitation of the participants was from a national MRI organization, the American Society of Radiologic Technologists (ASRT), and community workers within the profession. The control group of participants was solicited through community board postings. Only the New York/New Jersey metro area and the New Hampshire/Maine area participants were used for this study. These participants were of various age ranges, genders, and educational levels. ANOVA and regression analyses were used to analyze the data. The study showed mixed results indicating no significant STM difference in the overall memory scores of both groups F (1, 80) =3.061, p =.084, but it did show a significant difference in STM when it came to prospective memory, memory of planned events.

Short Term Memory of Magnetic Resonance Imaging Technologists

by

Samuel Maldonado

MS, Walden University, 2010

MS, Polytechnic University, 1996

BS, Herbert H. Lehman College, 1986

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Health Psychology

Walden University

May 2016

Dedication

I would like to dedicate this work to the most important influences of my life--God, my children, Nicole and Ivan, and my family--all who have provided unprecedented support in this challenging process. I am most deeply grateful for my faith in God, which has helped me through many difficult moments in the quest to accomplish this most rewarding endeavor.

Acknowledgments

I would also like to thank all the academic professionals that have been supportive in guiding me to this point, especially my committee members Dr. Stephen Burgess, Dr. Steven Linnville, Dr. Patricia Costello, Dr. Abby Harris and Dr. Wong whom have provided tireless guidance during this process.

Table of Contents

List of Tables

Chapter 1: Introduction to the Study

Preface

Magnetic fields are all around us today. They are in the homes (microwaves, refrigerators, heating blankets), the environment (cell towers, power lines), and in the place of work (MRI machines). With the growth of many industries that are using magnetic fields within their everyday functions, it was prudent to study the effects that these fields have on us physically. Within the medical field, working around magnetic fields is not foreign to the profession. In fact, MRI technologists work around the MRI machine's magnetic fields every day. This was the premise of this study.

The increase in the use of cell phones, tablets, and magnetic resonance imaging (MRI) equipment as well as the elevated levels of magnetic fields within the environment has become alarming to many, including researchers in the field of psychology. Much interest has surfaced in understanding what reaction is present in the atoms of an individual's brain, due to the increase in magnetic fields and how this reaction affects memory (Baddeley, 2004). This interest began with the launch of the first generation cellphone network by Nippon Telegraph and Telephone in 1979 (Dixon, 2012). It continued through other sectors of the technological expansion (Dixon, 2012). One such sector is that of the MRI industry.

With the growth of the MRI industry, many professionals that work with MRI machines have begun to question if any side effects are associated with being exposed to the MRI machine. Those within the psychology profession have also begun to look into what side effects could the MRI machines have on an individual. Although familiarity with specific components of the MRI machine are known, full knowledge of the short and/or long term side effects are not fully understood. What has been discovered are some of the side effects that are experienced by patients are directly linked to MRIs (e.g., dizziness, nausea, and nephrogenic systemic fibrosis; Eitel et al., 2010). However, further studies have to be completed before it is determined that MRI technologists experience any side effects.

Introduction

This chapter provides background information on the elements associated with this study. In this chapter, I look into the current known consequences of magnetic fields that are linked to MRI machines. I expose the need for further studies within the area of magnetic fields and the side effects experienced by exposure to them. I also illustrate a link between STM and the areas associated with STM concerning MRI exposure. In the chapter, I also provide evidence of the areas that are associated with STM and the loss of memory. Finally, I present information on where a gap exists in the literature; discuss the research questions; and list assumptions, limitations, scope, and delimitations to this study; and provide the social significance of the study.

Background

Dr. Damadian (Gould & Edmonds, 2011; Thomas, 2009) discovered the magnetic resonance imaging unit in 1977. Dr. Damadian worked on the machine with a number of students and upon completion no one would volunteer to take, the first image (Gould & Edmonds, 2011; Thomas, 2009).This compelled Dr. Damadian to be the first to take an image with the MRI machine (Gould & Edmonds, 2011; Thomas, 2009). Once taking the first image, extensive research began in the attempt to perfect the MRI machine and expand on its imaging capabilities (Gould & Edmonds, 2011; Thomas, 2009). At the current time, there is still ongoing research that is looking into better ways to elevate the level of imaging done on MRI machines. There is also ongoing research looking into determining if there are any side effects from repeated exposure to the magnetic fields used on the machines.

MRI Machine

The MRI machine uses a magnetic field to produce the image of a desired body part (Gould & Edmonds, 2011). In order to create this magnetic field, three designs of the MRI machines are used. One consists of a permanent magnet whose magnetic field is always present (Gould & Edmonds, 2011). The second uses a resistive magnet, which uses a wire that is wrapped around a core creating a magnet when an electrical current is run through it (Anlage, 2000; Stephen, 2011). The third is a superconductor that is similar to a resistive magnet, but maintains the coil dipped in liquid helium (Anlage, 2000). The liquid helium causes the resistance in the wire to reach a level of zero (Anlage, 2000; Stephen, 2011). The superconductor design is the magnet that is most used today (Hornak, 2011).

Magnetic Fields

MRI technologists are exposed to magnetic fields of various strengths during every work tour. The strength of the magnetic field is dependent on the distance the technologists are from the MRI machine (Kannala, Toivo, Alanko, & Jokela, 2009;

Skopec, 1997). Surrounding the MRI machine there exist a static magnetic field (SMF) and fringe magnetic field (FMF; Kannala, Toivo, Alanko, & Jokela, 2009; Skopec, 1997). The SMF is closest to the MRI machine and possesses the higher magnetic potency (Kannala, Toivo, Alanko, & Jokela, 2009; Skopec, 1997). The potency of a SMF could be within the range of 0.2 and 2.0 tesla or 5,000 to 20,000 gauss (Kannala, Toivo, Alanko, & Jokela, 2009; Skopec, 1997). In some research work environments, the magnetic field could be even higher.

The FMF is further away from the MRI machine making its strength weaker than that of the SMF. Within the FMF, there is an area with a lower potency magnetic field consisting of at least five gauss in strength and this area is called the “5 Gauss Zone” (Abbott Northwestern Hospital, 2009). When technologists are within this zone, they are exposed to a magnetic field, which is equivalent to five gauss in potency. This is the lowest magnetic field strength that is within the MRI technologist’s work area (Abbott Northwestern Hospital, 2009).

Magnetic Fields and Memory

Research has pointed to the influence that magnetic fields have on the memory performance of both animals and humans (Colbert, Markov, & Souder, 2008; Delparte & Persinger, 2007; Jerde et al., 2008; McKay & Persinger, 2005; Meli & Persinger, 2009; St-Pierre, Koren, & Persinger, 2007; St-Pierre & Persinger, 2006; Whissell et al., 2009). These studies have indicated that magnetic fields and/or magnetic pulses lead to behaviors that are both positive and negative in nature. For example, studies have shown how magnetic fields helped a prenatal rat maneuver a maze better (McKay & Persinger, 2005). Other studies conducted on humans were able to demonstrate how magnetic fields could provide treatments for bipolar disorders (Rohan et al., 2004). In another study on humans, magnetic fields were able to produce the viewing of “sentinel beings” (St-Pierre, & Persinger, 2006).

Research has shown that exposure to magnetic fields, even of low potency, has led to changes within areas of the brain associated with memory. These areas are inclusive of the hippocampus, the medial temporal lobes, and the frontal lobes (Squire, Stark, & Clark, 2004). Squire, Stark, and Clark (2004) pointed out how other related regions of the brain including the adjacent perirhinal, entorhinal, parahippocampal cortices, and hippocampal regions are also involved in memory. Studies conducted on animals and humans confirmed these regions of the brain as being associated with memory (Delparte & Persinger, 2007; McKay & Persinger, 2005; St-Pierre et al., 2007; Whissell et al., 2009). These studies also confirmed how magnetic fields or magnetic pulses have affected at least one of these areas, the hippocampus (Delparte & Persinger, 2007; McKay & Persinger, 2005; St-Pierre et al., 2007; Whissell et al., 2009). My study looked into the effects of the magnetic field exposure that technologists faced on STM functions.

Other studies have indicated further evidence on the magnetic field’s influence on the memory structure. Some studies confirmed that exposure to magnetic fields could cause amnesic-like symptoms and behavioral changes (Delparte & Persinger, 2007; St-Pierre et al., 2007). Where other animal studies and human studies have demonstrated that exposure to a constant magnetic pulse caused structural changes within the hippocampus (Delparte & Persinger, 2007; McKay & Persinger, 2005; Squire, 1992; St-Pierre et al., 2007; Whissell et al., 2009). This occurred when exposure to a complex magnetic field in the range from <5nT to 1mT during irregular time frames was experienced by a prenatal rat (Delparte & Persinger, 2007; McKay & Persinger, 2005; Squire, 1992; St-Pierre et al., 2007; Whissell et al., 2009). Finally, magnetic fields were able to influence various behaviors performed by Wistar male rats, such as ambulation, defecation, and grooming (St-Pierre et al., 2007).

Side Effects in Humans

It is still unknown whether SMF/FMF cause any side effects in general on MRI technologists' STM. Research that focuses on STM and MRIs SMF/FMF is still limited. This study provided some foundation for this type of research. In this study, I looked into what difference exists between the STM of MRI technologists exposed to the SMF/FMF and non-MRI technologists. I did this in the hopes of opening a dialogue around this topic and provoking interest into further research in this area.

This study was justified due to the lack of research that looks into the influence on MRI technologist's STM memory when exposed to a STF/FMF. Many animal and human studies looked into how a pulsed magnetic field influences STM memory, but not many looked into the effects of what exposure to a STF/FMF does to an individual's STM memory. Some studies have looked into the effects on patients that faced exposure of a constant magnetic field for a short period, like that produced by MRI machines (Eitel et al., 2010). These studies have demonstrated that patients exposed to the strong constant magnetic fields, when taking an MRI, do experience negative side effects (Eitel et al., 2010). However, little research is available looking into the exposures faced by MRI technologists. These reasons provided the foundation for this study.

Finally, the study was also justified by the desire to expose any changes that could benefit all exposed to the MRI machine's magnetic fields. Modifications within the safety procedures used to protect the patients, the public, and MRI technologists could be a benefit of this study. This study could also lead to design and shielding modifications for MRI equipment used for imaging. A clearer understanding of SMF/FMF and the possible results of exposure to these types of magnetic fields were parts of the goal of this study. The sparking of interest in the need for further studies on SMF/FMF was another goal of this study.

Memory

A large component of memory research is on amnesic patients. One such case was that of H. M.. H. M. was a patient whom researchers were able to follow over an extended period of time (Newhouse, 2007; Squire, 1992). H. M. had a procedure done which removed a portion of his left and right medial temporal lobes due to severe convulsions caused by seizures (Pinel, 2006, pp. 261-263)This lobectomy included the removal of the hippocampus, amygdala, and the adjacent cortex (Pinel, 2006, pp. 261-263) One specific discovery was that the regions removed from H.M.'s brain were necessary in memory and in the formation of new memory (Pinel, 2006, pp. 261-263).

After his lobectomy, H. M. was shown to suffer from anterograde amnesia (Pinel, 2006, pp. 261-263). H. M. was unable to remember any new information and. most of the information that was presented to H. M. would only remain within his short-term memory STM, before it was completely forgotten. None of the information that was presented to H. M. ever made it to his long-term memory (LTM; Pinel, 2006, pp. 261-263). This prevented H. M. from learning new material.

The discoveries that surfaced due to continuous research conducted on H. M. had led many within the psychological community to a better understanding of how the memory system works. It has also directed the understanding of various theories associated with memory. It has steered the research arena to study specifically targeted regions of the human brain. These regions are involved in the manipulation of stimuli, in the formation of memory, and in the process of learning (Squire, Stark, & Clark, 2004) . Squire, Stark, and Clark (2004) pointed out how some of the regions of the brain associated with memory are the hippocampus, the medial temporal lobes, and the frontal lobes. These discoveries helped guide researchers in the psychological community.

History on Memory

In the 1960s, the understanding of memory began with the embracing of a unitary system (Baddeley, 2004; Balota & Cortese, 2000). This system bulked all memories into one structure and did not separate the functions of any of the memories into their own segments (Baddeley, 2004; Balota & Cortese, 2000). It was believed by professionals that stimuli made it to LTM once being processed through the unitary system (Baddeley, 2004; Balota & Cortese, 2000). This theory did not come without its critiques. It was seen by many professionals as counterproductive and having limitations. This theory was changed to the Atkinson-Shiffrin model of memory with time after studies with amnesic patients revealed that there exists a separation between STM, LTM, and working memory (WM).

Theories on Memory

Other theories that surfaced since that time were the Atkinson model of memory, Shiffrin model of memory, James Jacobs's model of memory, and the Brown-Peterson model of memory (Baddeley, 2004). All of these theories were based on research conducted on amnesic patients (Baddeley, 2004).These patients were able to remember digit spans that were presented on a short-term basis, but were not able to remember the digit spans over the long term (Baddeley, 2004). This in many respects confirmed that two separate memory components are part of the memory system. Baddeley (2004) confirmed this by pointing out the various sectors used in creating memory: the environmental input, the sensory registers, the short-term store (STS), and long-term store (LTS). Memory problems were presumed to be part of a deficit within any of these memory storage facilities (Baddeley, 2004; Balota & Cortese, 2000).

In the 1970s, this concept was one that focused on having a WM with levels of processing. WM was seen as the area where any information or stimuli was gathered from the environment and processed in segmented order (Baddeley, 2004; Balota & Cortese, 2000). One part of working memory was considered to be STM. STM could be viewed like a sketchpad where information was kept for a short period of time (Baddeley, 2004). Further discoveries led to the better understanding of working memory and how in order to remember things better in-depth processing should be used (Bartlett & Tulving, 1974). This discovery satisfied the notion that information processed in a semantic manner would have a better chance of being stored in LTM (Bartlett & Tulving, 1974). This also confirmed that STM and LTM were two separate areas of the memory system (Bartlett & Tulving, 1974).

Further confirmation of the elements associated with WM were discovered by (Baddeley, 2004; Balota & Cortese, 2000) and through studies conducted on H. M., the amnesic patient. Baddeley (2004) pointed out how WM consisted of various forms of processing. The separation of processing allowed for portions of STM to be functional while other sectors were unable to process stimuli appropriately (Baddeley, 2004). For example, sections of the phonological processing could be operational while the visuospatial sectors were not (Baddeley, 2004). This led to the processing of only portions of the presented material being learned. An example of this could be seen with the case of H. M. who had problems processing and learning new material, but no deficit in processing or learning some semantic information (Newhouse, 2007).

Due to the findings mentioned above, the Baddeley and Hitch model of working memory was the candidate of explaining memory and was commonly accepted as an explanation of learning (Baddeley, 2004). The Baddeley and Hitch model embraced a visuospatial sketchpad and its phonological loop with a central executive processing unit to process memory (Baddeley, 2004). This model provided guidance on the understanding of STM. It helped provide a link between other theories of STM memory like the Brown-Peterson theory of memory and led to the understanding that STM could be manipulated and was separate from LTM (Crowder, 1967).

Brain Sectors Involved in Memory

The various sectors of the brain involved in the processing of material within the memory hierarchies could be isolated to the frontal lobe, temporal lobes, and the hippocampus (Baddeley, 2004; Demakis, 2004). The frontal lobe is functional within the executive processing of material and any deficits within the frontal lobe could lead to problems in memory and learning (Baddeley, 2004; Demakis, 2004). The hippocampus is involved in the processing of material for the eventual storage of the stimuli into LTM (Baddeley, 2004; Demakis, 2004). Confirmation of the various memory sectors was seen in the studies conducted on H. M. (Newhouse, 2007).

H. M., due to a procedure conducted to remove part of his temporal lobe which included the hippocampus, was only able to learn and remember selective semantic material (Newhouse, 2007). Baddeley (2004) pointed out that these three components are part of the Papez Circuit; this is the area thought to be involved in developing or storing LTM. Any flaw within one of the components will prevent proper functioning of the LTM region (Baddeley, 2004; Demakis, 2004).

Other discoveries exposed the separation of implicit and explicit memories and their involvement in the retrieval and creation of memory. It was discovered that implicit memories could be retrieved without a connection to LTM (Baddeley, 2004). Therefore, a direct link to LTM was not necessary for individuals with amnesia to be able to recollect material that was implicit and semantic in nature (Newhouse, 2007) This has steered some to view the recollection process as one that uses all areas of the brain to remember material that is implicit in nature (Newhouse, 2007). Other studies led to the understanding that explicit memory involves certain specific components of the brain (Baddeley, 2004). If any are affected, deficits in the retrieval or storing of new memories could surface (Baddeley, 2004, pp. 1-13).

Elements That Could Distort Memory

Now that these basic components of the memory system are identified, the focus is shifted to elements which could distort memory or complicate the creation and recollection of memory. With respects to this study, the focus was to determine the relation of long-term exposure to magnetic fields in the work place (i.e., MRI technologists) to STM ability. Specifically SMF and FMF as produced by MRI machines were considered. This study examined if an MRI technologist's exposure to a SMF/FMF was associated with poorer STM performance.

Statement of Problem

The various regions of the brain involved in the formation of memory and the necessity for the involvement of these areas when it comes to learning cannot be ignored. The difficulty and challenges that are represented when individuals are involved in learning new material or the complexities that are associated with the recollection of old material cannot be overlooked. Although this study focused on the effects of SMF/FMF on STM, other studies have shown how magnetic fields in general have influenced memory and other areas of the cerebral structure. For example, research on nonhumans has shown how a complex magnetic field ranging from <5nT to 1mT delivered in irregular time frames caused changes within an animal's cerebral structure (Whissell et al., 2009). In another example on nonhumans, a 15-minute daily exposure to a complex magnetic field of 0.5 to 1 micro T was responsible for changes within cell densities and the hippocampus of rats (Whissell et al., 2009). These studies on nonhumans expose the effects of magnetic fields on the various regions of the brain, which elevates the need for research expanding on this knowledge base.

Technologists are exposed to MRI machine's magnetic potencies throughout their careers. The MRI machine's magnetic field that MRI technologists face on a daily basis is equivalent to at least five gauss in potency. MRI technologists are expected to work with patients within the MRI machines' vicinity and this exposes them to very high levels of magnetic fields. Non-technologists are only exposed to this level of magnetic field when they are required to take an MRI due to health reasons. The FMF/SMF that is within the confines of these machines could range depending on the distance that the technologists are from the MRI machine. When the technologists are the closest to the machine, the exposure is the highest, equating to the tesla level of the MRI machine (FDA, 2015) The measurement of the total exposure that a technologist faces throughout their career is difficult to determine because many technologists work with machines of different tesla levels.

However, it could be assumed that the level faced by a technologist daily is at least five gauss in potency. This level is only limited by the organization where the technologists work, based on the equipment that is used in the facility. This level alone is associated with changes within the technologists' cerebral cortex where magnetic fields of low potency are associated with outcomes in humans such as the viewing of sentinel beings and changing of behaviors (Colbert, Markov, & Souder, 2008; Delparte &

Persinger, 2007; Jerde et al., 2008; McKay & Persinger, 2005; Meli & Persinger, 2009; St-Pierre, Koren, & Persinger, 2007; St-Pierre & Persinger, 2006; Whissell et al., 2009). The effects of the magnetic field that MRI technologists are exposed to during their careers are still unknown.

Positive Uses of Magnetic Fields

Research has shown how low-field magnetic fields are effective in the treatment of various psychological and physical challenges. Rohan et al. (2004) pointed out how low-field magnetic fields were effective in the treatment of bipolar disorder. The study looked into how an echo-planar magnetic resonance spectroscopic imaging (EP-MRSI) procedure could influence the mood of bipolar disorder patients. The results indicated that 23 out of 30 bipolar patients exposed to the EP-MRSI procedure did experience mood improvements (Rohan et al., 2004). Vavken, Arrich, Schuhfried, and Dorotka, (2009) pointed to the treatment of osteoarthritis as further evidence of positive uses of low-field magnetic fields. In their study, a pulsed magnetic field of 3Hz to 7.8Hz and up to 27 MHZ was applied to the patient’s arthritic knee for 10 minutes, three times a day. Their results indicated that the patients had improved function and reduced pain.

Negative Results Due to Magnetic Field Exposure

On the other hand, patients experiencing side effects that included burns and the disease of nephrogenic systemic fibrosis (NSF; Ortega et al., 2009; Rota, Natllino, Bainotti, & Formica, 2010) noted negative consequences. Nephrogenic Systemic Fibrosis (NSF) and nephrogenic fibrosing dermopathy (NFD) are the result of a combination of having a dye, gadolinium, injected into the body, being exposed to an MRI, and the patient's body not being able to dispose of the dye (Ortega et al., 2009; Rota et al., 2010). This dye mainly causes challenges to those that suffer from kidney problems (Ortega et al., 2009; Rota et al., 2010). Other side effects that have been reported by patients undergoing MRIs are dizziness, stomach-upsets, and metallic taste (Medical-Siemens, 2013). Some patients have even complained of feeling claustrophobic when in the machine's bore (Medical-Siemens, 2013).These negative experiences have lead many patients to refuse to take images with the use of an MRI.

Based on previous research, it becomes important to explore what further effects do magnetic fields have on MRI technologists. Magnetic fields, in general, do influence a part of the brain that is associated with memory, the hippocampus. For this reason, many want to determine if a constantly existing magnetic field could lead to potential changes within memory (Rohan et al., 2004; St-Pierre & Persinger, 2006). With respects to this study, the effect of a SMF/FMF that is a part of the MRI machine was of interest. The individuals that work around the MRI machine were of importance, due to their prolonged exposure to the machine's magnetic fields.

Known Health Issues Associated With STM

There have been extensive studies conducted that looked into a person's health and their loss of memory (Foster, 2011). For example, some known facts are that a person that suffers from dementia will experience a loss of memory over time (Foster, 2011). Other known facts are that memory tends to dissipate with age and that thyroid problems could cause memory deficits (Wallace, 2012). It is because of this that part of the study included a questionnaire with health questions. The health questions included in the questionnaire helped in the elimination of health factors that could cause memory loss.

Purpose of the Study

The purpose of the study was to quantitatively examine if individuals who work around the residual magnetic fields surrounding the MRI machines demonstrated differences in their STM when compared to individuals that do not work around MRI machines. In other words, do the STM of MRI technologists differ when compared to the STM of non-technologists? This study looked into the memories of those exposed to prolonged residual magnetic fields as compared to those that are not exposed to the residual magnetic fields. Finally, the study looked to report any serendipitous data that surfaced due to this study.

The study looked into quantitatively analyzing whether the memory score, health elements, and technologists' tenure differed between the MRI technologists group and a control group. The study determined if there was a difference between the mean memory scaled scores of non-MRI technologists versus that of the MRI technologists. My study also examined the extent to which demographic factors such as age, gender, and health factors (i.e., thyroid problems) were associated with differences in memory and whether work factors among the MRI technologists (i.e., type of machine used, number of years exposed to the machines) influenced the STM scores of technologists. These results all took into account the elimination of as many confounding variables as possible. The results (memory score) also depended on a number of variables including whether a magnetic field existed outside of the shielding, whether the magnetic field was always present, and what the level of the magnetic field was during the technologist’s work tour.

Research Question

In an effort to determine the effect of existing SMF/FMF that surrounds MRI machines on the STM of MRI technologists, a theoretical basis for this study had to be determined. This theoretical foundation is based on the previous nonhuman and human research conducted on using magnetic fields. With research looking into the components associated with MRI’s effects on patients, not much existed that places the technologists at the forefront of its study. Further, in consideration of MRI technologists’ constant exposure to the MRI machines’ SMF/FMF, it was prudent to explore the outcome of the difference between individuals that do not experience this same exposure (Skopec, 1997). MRI technologists are required to prepare patients within the SMF/FMF area. These areas have a SMFs/FMFs of between 0.2 and 2.0 tesla in potency and sometimes higher (FDA, 2015). Limited studies existed that looked to determine what this level of exposure has on the technologist’s STM,

A few studies have examined magnetic field exposure in patients with short-term exposure. No studies were identified that examined the relations of prolonged magnetic field exposure such as that experienced by MRI technologists on STM. This study examined the STM of technologists that are exposed to a MRI machine’s magnetic field. This magnetic field is within the 0.2 and 2.0 tesla levels when the static magnetic field is examined. The memory scores of MRI technologists versus that of non-MRI technologists were assessed.

This study used a quantitative design. The goal of the present study was to examine group differences in STM between those exposed to prolonged magnetic field exposure and those without a history of such exposure. Using a quasi-experimental design, the STM of MRI technologists was compared to the STM of non-MRI technologists. The quasi-experimental design was used as random assignment and manipulation of the independent variable was not possible. A related goal of the study was to examine the relationship of STM ability to tenure as an MRI technologist, the type of machine used, and amount of hours worked.

Administration of The Rivermead Behavioral Memory Test-Third Edition (RBMT-3) was a tool for gathering data for the results. The tool was designed to test the memory of individual's everyday functions (Wilson et al., 2012). Finally, this research looked to answer the following central question: What affect did the SMF/FMF have on the MRI technologists' STM?

Research Questions and Hypotheses

Research Question 1: What was the difference between the STM of MRI technologists and non-MRI technologists?

Directional Hypothesis 1 It was expected that MRI technologists that worked within the confines of MRI machines displayed differences in STM as measured by the RBMT-3 when compared to non-MRI technologists.

Null Hypothesis 1: It was expected that MRI technologists that worked within the confines of MRI machines did not display differences in STM as measured by the RBMT-3 when compared to non-MRI technologists.

Research Question 2: What was the difference between the STM of MRI technologists versus non-MRI technologists when accounting for all demographic variables?

Directional Hypothesis 2: It was expected that MRI technologists' STM would differ when compared to non-MRI technologists when including demographic variables.

Null Hypothesis 2: It was expected that MRI technologists' STM would not differ when compared to non-MRI technologists when including demographic variables.

Research Question 3: How much variance in STM is explained by the MRI technologists' status after accounting for demographic variables?

Directional Hypothesis 3: It is expected that MRI technologists' work status variables will explain a significant variance in STM after accounting for demographic variables .

Null Hypothesis 3: It is expected that MRI technologists' work status variables will not explain a significant variance in STM after accounting for demographic variables .

Confounding Variables

In order to address confounding variables, a questionnaire was included before the RBMT-3 was administered. This questionnaire looked to obtain information from the participants about their behavior before the study was conducted. Potential exclusion from the study was dependent on the responses to specific questions by the participants. The questionnaire was a tool used to hold variables constant. Some of the variables had posed challenges in the recollection of memory. The questionnaire was also used to establish the demographic information of the participants. The questionnaire is included in Appendix C.

Definitions of Theoretical Constructs

The varying theories associated with memory are vast and many of the currently acknowledged theories are still being intensely studied. In the 1960s, the unitary system of memory was established and followed, but it is no longer the system commonly accepted and used to explain the workings of memory (Baddeley, 2004). The development of the modal model indicated that all LTM is developed by passing through STM (Baddeley, 2004). This theory guided the current understanding of memory into a two-segmented system (Baddeley, 2004).

Following this theory, Baddeley (2004) injected the concept of working memory into the current theories. The Baddeley and Hitch model of memory embraced a system that used multiple levels of processing in order to store material into LTM (Baddeley, 2004; Raaijmakers, 1981). This established two STM stores with a phonological loop and a visuospatial sketchpad (Baddeley, 2004; Raaijmakers, 1981). Basic practical solutions were also seen as necessary for the storage systems to function up to their full potential, such as that of chunking (Gobert & Clarkson, 2004). For the purpose of this study, Atkinson and Hitch's model of memory current theory for STM was used. This theory places STM in one compartment (Baddeley, 2004) . Atkinson and Hitch's theory also found all memory sources to be part of a general structure necessary in the processing of stimuli and the creation of new LTMs (Baddeley, 2004; Raaijmakers, 1981).

On the magnetic field end, the discovery of MRI machines and the necessity for a strong magnetic field to be present when taking images is still not fully understood. Many professionals are still attempting to determine if there exists any real harm associated with taking an MRI. Some of the things that are known are that MRI machines use a strong magnetic field in order to take quality images. Taking an MRI could cause side effects that include burns, dizziness, stomach upsets, and diseases such as NSF (Medical-Siemens, 2013; Ortega et al., 2009; Rota et al., 2010). Ortega et al. (2009) and Rota et al. (2010) pointed out that patients with metallic internal implants cannot take MRIs.

This study presented it's own set of challenges. There were some unknown variables, which could have also been involved in the loss of STM and influenced the results of this study. In many respects, holding all contributing factors that were associated with the loss of memory constant was impossible. Challenges with all presented data were addressed through the statistical analyses. The test tool was also used to address some challenges, such as age. The test tool allowed for the conversion of raw scores into scaled scores accounting for age.

It is worthy to note that the elevated magnetic field is only present when the MRI machines are activated, unless the permanent magnetic system is used (FDA, 2015) Therefore, the only individuals that are exposed to the strong magnetic field at the time that imaging is taking place, for the most part, are the patients that are under the machine's influence. However, common industry practice is to leave an MRI machine activated at all times, once the initial activating sequence is conducted (for resistive magnetic machines and superconductors; (FDA, 2015). The only time any of the resistive/superconductor machines are “shut down” is during an emergency, where the machine is quenched (FDA, 2015) The practice of leaving the machine on at all times exposes MRI technologists to the machine’s magnetic field, while they are in the room where the machine is housed (Siegel, 2008).

This study was mainly interested in the difference in STM between MRI technologists and non-technologists. This is further elaborated in Chapter 2. The fact that magnetic fields do influence the brain has been shown with recent animal and human studies, which was the theoretical framework of this study (Colbert et al., 2008; Delparte & Persinger, 2007; Jerde et al., 2008; McKay & Persinger, 2005; Meli & Persinger, 2009; Rohan et al., 2004; St-Pierre et al., 2007; St-Pierre & Persinger, 2006; Whissell et al., 2009). This framework provided for the linking and justification of the conceptual significance of the study. In other words, since it is known that magnetic fields influence changes within the brain and considering that MRI technologists work around a magnetic field, than testing for loss of memory is conceptually realistic and logical.

Operational Definitions of Terms

Episodic memory: Specific memorization of events and experiences stored in LTM (Baddeley, 2004).

Explicit/declarative memory: The recollection of facts and events. (Baddeley, 2004).

Exposure: The participant’s risk of being within the area of the five gauss zone or anywhere within the vicinity of the SMF/FMF (Gould & Edmonds, 2011; Thomas, 2009)

Fringe magnetic field: This magnetic field occurs as one walks away from the MRI machines isocenter/bore (Gould & Edmonds, 2011; Thomas, 2009).

Frontal lobes: An area of the brain responsible for the motor functions, higher order functions, planning, reasoning, judgment, impulse control, and memory (Pinel, 2006, pp.67- 69).

Hippocampus: A part of the brain that is associated with long-term memory and learning (Baddeley, 2004; Sutherland, Lehmann, Spanswick, Sparks, & Melvin, 2006).

Implicit/nondeclarative memory: A form of conditioning, skills, habits, and priming associated with memory (Baddeley, 2004).

Limbic system: The part of the brain responsible for emotions and memory. Parts of the limbic system include the amygdala and the hippocampus, which are associated with memory (Pinel, 2006, pp. 261-263).

Long term memory (LTM): Information that is held in memory for longer periods of time, usually for an indefinite period of time (Baddeley, 2004).

Magnetic field: Any area that is within the vicinity of the MRI machine, usually having a magnetic potency of at least five gauss. The magnetic field in the vicinity of a MRI machine could be even stronger (Gould & Edmonds, 2011; Thomas, 2009)

Papez Circuit: Linking of the hippocampus, temporal lobes, and frontal lobes is considered the Papez Circuit (Baddeley, 2004).

Phonological loop: Consists of the part of working memory that is believed to hold memory for a couple of seconds, which is combined with a subvocal rehearsal process (Baddeley, 2004).

Residual magnetic field : Any magnetic field within the vicinity of the MRI machine, this magnetic field is usually at least five gauss in strength (Gould & Edmonds, 2011; Thomas, 2009)

Rivermead Behavioural Memory Test-Third Edition (RBMT-3): A test tool used to test memory, both STM and LTM (Wilson et al., 2012).

Semantic memory: Information that is factual and stored within the memory structure (Baddeley, 2004).

Short term memory (STM): The ability to repeat information that has been in memory for a short period of time. This is said to be limited in digit span (Baddeley, 2004).

Static magnetic field (SMF): This magnetic field is created by the MRI magnets at the isocenter or bore of the MRI machine. This magnetic field is always present (Gould & Edmonds, 2011; Thomas, 2009)

Temporal lobes: The temporal lobes are the controlling elements behind the control of auditory perception, memory, speech, emotional responses, and visual perception (Squire et al., 2004).

Working memory (WM): Storage mechanisms that are used for a short duration of time (Miller, Watson, & Strayer, 2012)

Assumptions, Limitations, Scope, and Delimitations

Limitations

There were numerous limitations that were a part of this study. Some of these were due to the participants of the study and their age, health, and physical limitations. For example, the current understanding of how the memory system works is limited to the current theories available. Therefore, it was assumed that the theories currently followed were concrete enough to be used in the explanation of the findings. This limited the understanding of the findings to today's established concepts on memory.

Another limitation experienced was in the lack of access to the physical sites for measuring magnetic fields. It cannot be confirmed that a magnetic field was present within the confines of the MRI technologist's work environment. In addressing this limitation, it was assumed that in order to complete an imaging some form of magnetic field had to exist (Siegel, 2008). It was also addressed by inserting questions into the questionnaire asking technologists about their current work environment, such as the type of machines that they worked on, the length of time they worked as technologists, and the amount of hours per day that they worked. Another limitation was experienced in the gathering of enough MRI technologists and control group participants that agreed to participate (Alsaleh, 2013). A further challenge was experienced with the use of intact groups versus random groups (Alsaleh, 2013). Since this was a quasi-experimental design study, there was no direct manipulation of an independent variable of long-term exposure to a magnetic field. The limitation associated with holding all confounding variables constant presented challenges. Finally, a survey designed to measure a variety of demographic variables was included to test for differences between the MRI technologists and the control group participants.

Although it was impossible to address all variables, some were addressed by direct query of the participants and others through the statistical analyses used. In order to address confounding variables due to a quasi-experimental design study, specific tools were used. For example, in order to address the confounding variable of age the raw scores of all participants were converted to scaled scores. This was done according to the scoring protocols of the RBMT-3, the test tool of STM used. The assessment tool provided for the scaling of the scores for each subsection of the assessment. Other variables were addressed through statistical methods, such as the use of an ANOVA to compare the groups on variables such as health issues and tobacco use. Group differences were tested based on their responses to the questionnaire; for example, the variables such as tobacco usage, health issues, and alcohol usage were identified by directly querying the participants through a questionnaire before comparing them on the health related factors.

It should be understood that this was a quasi-experimental design and unfortunately, this particular design had to be used due to the lack of manipulation of a variable and the use of intact groups versus randomly assigned groups (Alsaleh, 2013). Finding technologists that worked with MRI machines right after receiving training at a young age was not a guarantee and presented some challenges. It would also not be possible to conduct an experiment of this nature due to practical and ethical issues. Practically, obtaining access to MRI facilities in order to conduct a study would be complex and difficult to accomplish. Ethically, researchers are not permitted to place humans in a position where they could be harmed. One final challenge was experience due to the nature of this type of research design. Although other professionals are exposed to magnetic fields at their work environment, only MRI technologists could be used. The decision was made to use this group because they are exposed to a SMF/FMF during their work tour.

Addressing Memory Deficits Caused by Age

Although there has been research indicating that memory tends to dissipate with age, this did not present a challenge for this study. The RBMT-3 assessment tool allowed for the scaling of the participant's results based on age. This scaling helped address any deficit due to aging. The test tool provided a conversion chart that converted each raw score into a scaled score. This scaled score was the result of including age as an element for the final raw score achieved by the participant. This scaling of the raw score was available for all sections of the assessment and for the sum of all the raw scores.

Assumptions

One assumption that was present in this study was the understanding of physics where any action leads to a reaction. It must also be assumed that if an MRI machine is housed within the confines of a location, a residual magnetic field must exist and in fact, this has been demonstrated to be the case (Skopec, 1997). It could also be concluded that the magnetic field will be at least in the area of five gauss in potency, since the current environment and guidelines set by the FDA are for sites to follow a five gauss zone (Skopec, 1997; U.S. FDA, 2011). Another assumption could be concluded in understanding that if a technologist has completed imaging of a patient than some form of magnetic field was used. One final assumption would be to conclude that technologists are exposed to a consistent magnetic field within their work environment every day.

In an effort to provide for a confirmation of various assumptions, MRI technologists were queried via the use of a questionnaire and through verbal confirmation. Some of the questions asked were inclusive of the existence of a five gauss zone at their place of employment. Other questions addressed the type of equipment MRI technologists had worked with. This included the types of MRI machines that they had been exposed to during their careers. Another question addressed whether the technologists worked with other forms of imaging equipment.

One assumption present is based on the individual's exposure to a SMF/FMF. For both the MRI technologists and non-MRI technologists it could be assumed that if a person is exposed to any form of magnetic field some form of atomic manipulation occurs. This manipulation could cause an immediate reaction as is the case with patients or it could cause long-term consequences. This is the case for those that are under the MRI machine's domain. The patients that are placed in the MRI's bore experience a manipulation of their atoms, where their atoms are inclined to stop spinning within their own axis (Sharma & Lagopoulos, 2009, 2010).

Ionizing Radiation/Nonionizing Radiation

For purposes of this study a differentiation should be drawn between the ionizing radiation (IR) used for X-ray machines and computed tomography (CT) versus the nonionizing radiation (NIR) used with MRI machines. Exposure to IR could lead to serious consequences due to the radiation that is part of the imaging process. However, exposure to NIR is not one that risks the individual of being in the presence of radiation. It must be noted that although familiarity with the long-term consequences associated with exposure to IR is known, the long-term consequences of exposure to NIR is still being studied. The lack of long-term existence of these machines has not allowed for extensive research in this area. Therefore, assumptions have to be made based on the current knowledge of NIR producing machines (Sowa, Rutkowska-Talipska, Sulkowska, Rutkowski, & Rutkowski, 2012).

Assumptions had to be made in various areas, which included the current understanding of NIR producing machines, the place of employment and the personal limitations of the MRI participants. Assumptions on what effect the NIR machines have on individuals. As well as, the functions of NIR machines based on the current knowledge of NIR producing machines (Sowa, Rutkowska-Talipska, Sulkowska, Rutkowski, & Rutkowski, 2012). Other assumptions occurred in the technologists' work location and the area where the MRI machine is housed. This assumption presumed that a SMF/FMF existed within the confines of the MRI technologists work location.

It had to be assumed that the results were due to the MRI technologist's work environment and that other variables did not cause the assessment results. It also had to be assumed that companies, which hired technologists, had tested said employees for any possible issues that hamper their ability to perform their duties as a technologist. An assumption had to be made that technologists experienced normal sleep patterns, as part of their everyday function. Additionally, it was assumed that technologist's memory capacity before working within the MRI environment was determined to be comparative to that of non-technologists. These assumptions helped shape the design of this study, along with the use of the questionnaire

FDA Recommendations

It should be noted that the FDA sets guidelines through the Food Drug & Cosmetic Act Chapter 5 Drugs and Devices for the installation and for the magnetic field that exist within the vicinity of the MRI machine (FDA, 2015). Compliance with the FDA requirements is entirely up to the manufacturers that are installing the equipment. The medical facility that is having the equipment installed is also responsible for compliance with the FDA requirements. Therefore, it becomes complicated to confirm the residual magnetic field that exists within all medical facilities. In an effort to address this problem, the technologists were asked a question confirming the existence of a five gauss zone within the confines of their work environment.

Weaknesses with the Study

Some of the potential weaknesses were seen in the lack of information available within this field. There are limited studies available that look into the direct influence that SMF/FMF has on the MRI technologists' memory. Further, valid professional writing within this sector was difficult to locate. Not many peer reviewed literature articles existed in the area of MRI and magnetic field influences, especially strong magnetic field influences or SMF/FMF. It was difficult to locate many studies that looked into the influences of MRI's magnetic fields on memory. This demonstrates the need for further study in this area.

Another weakness was presented with the population base. Due to the nature of this study, only a particular population base was used. This limited the selection process and made it more difficult to locate participants. The population consisted of MRI technologists who are a broad and vast population, with respects to their work assignments. With respects to the control group, the selection of participants was accomplished with the use of local postings within the local community. This limited the pool of participants.

Scope

This study was focused on the magnetic fields that exist within the vicinity of MRI machines. These magnetic fields are of various gauss levels and are dependent on the distance that the person is from the MRI machine. There are at least three levels of magnetic fields within the vicinity of an MRI machine. These three levels formed the foundation of this study. Within the immediate vicinity of the MRI machine there exists a static magnetic field. This magnetic field is the highest level of magnetic field that the MRI technologists are exposed to. Moving further away from the MRI machine there exist a fringe magnetic field, which is the second field and then outside the room is the next magnetic field. These guidelines are set by the FDA and are followed by the facilities.

Moving outside of the room that houses the MRI machine there exist a “5 gauss zone.” The “5 gauss zone” is an area that is stipulated by the FDA. This area contains the least amount of magnetic field that the MRI technologist faces. This is the location where the MRI machine’s computer system is kept and where the MRI technologists spend most of their time. This study looked into whether exposure to these magnetic fields was associated to STM loss. MRI technologists were used for this study because of their continuous work related exposure to these three magnetic fields.

Social Significance

The significance of this study was driven by the desire to determine if a difference existed in STM between MRI technologists and non-MRI technologists. The study also provided for a better understanding of the significance that magnetic fields have on the lives of MRI technologists. Further significance could come from necessary changes that the study has exposed. It was also significant to determine the daily challenges that MRI technologists face because of being exposed to a SMF/FMF over time. Finally, the study provided for a foundation for further research within the area of magnetic fields.

The social ramifications of this study could be seen in its influence in igniting further research on magnetic fields. It could lead to changes and protection against magnetic fields, if they are indeed hazardous. It could lead to studies that focus on the health consequences associated with magnetic field exposure. It could lead to further studies providing a better understanding of how magnetic fields influence the cerebral cortex and the various sectors involved in memory. It could also lead to an exploration into the positive and negative uses of magnetic fields.

Summary

The desire to create equipment that could give medical professionals imaging of the human structure, led to the discovery of the MRI machine (Cheong & Muthupillai, 2010; Hornak, 2011). Dr. Damadian and a number of students were the first to present some success with these machines (Gould & Edmonds, 2011; Hornak, 2011). The expeditious arrival to the market of the MRI machine did not leave much room for extensive research. Research that looked into the possible negative consequences associated with the machines' magnetic field, for both the MRI technologists and non-MRI technologists, was not a priority. Some 38 years later, there remains a paucity of research examining the consequences of long-term exposure to the magnetic fields used in MRIs (Cheong & Muthupillai, 2010; Eitel et al., 2010).

Chapter 2 reviews existing literature within the area of magnetic fields and their influence on parts of the brain, including the components that are associated with memory. The chapter begins with a history of how the MRI machine was invented, which provides a background on the MRI. The various forms of creating an image through the differing types of machines are presented, followed by theories that were associated with STM. Chapter 2 continues with animal and human studies that had shown how magnetic fields influenced parts of the brain, which was the theoretical framework of this study. Chapter 2 presents literature that looked into the negative influences of magnetic fields on the brain and how magnetic fields were used in positive ways.

Chapter 2: Literature Review

Introduction

The literature in this chapter establishes a need to research the area of what effects MRI machines' SMF/FMFs have on technologists that work with these machines. My review of literature establishes the positive uses of magnetic fields. Since the inception of MRIs, the goal of many professionals has been to determine if exposure to the MRI machine's strong magnetic field causes any side effects (Ortega et al., 2009; Rota et al., 2010). My goal in this chapter was to bring forth literature that contributed to our understanding of MRIs and magnetic fields. In this chapter, I also present what effects residual magnetic fields have on humans and animals and provide for an understanding of the area of the brain that magnetic fields influence.

In this chapter, I provide some background historical information on how MRIs are produced, on the various imaging equipment, and how STM was discovered. The side effects associated with MRIs and their strong magnetic fields along with the components necessary for the creation of the imaging that is seen with MRIs are also discussed. In addition, the classification of STM and its limitations are discussed along with its difference with respects to cognition. In the chapter, I also address some of the safety components that are tenets of the profession and look into the various areas of the cerebral cortex associated with STM. The effects that magnetic fields have on STM and the theoretical explanations of how MRIs are produced or the effects they may have

In this chapter, I provide for an objective discussion by challenging some of the outcomes reached in some of the studies. For example, what area of the brain is responsible for STM. In other areas of the chapter, I provide support for the results of other studies. I also provide some evidence where magnetic fields could be used in positive ways and present studies that focused on elements that effect STM. The chapter culminates with an indication of what past research has discovered and how it has influenced current research. A search for literature was conducted digitally with the Internet and the Walden library. Searches were conducted through various sites including medical and psychology databases such as PsycINFO, PsycARTICLES, MEDLINE, Medscape, and the Walden University library database.

MRI Machines

MRI machines use a strong magnetic field. This magnetic field is measured in tesla levels; where one tesla equates to 10,000 gauss in potency (Colbert et al., 2008; Gould & Edmonds, 2011; Hornak, 2011). In comparison the strength of the MRI machines used today are equal to 0.50 tesla to 7.0 tesla, or 5,000 to 70,000 times the earth's magnetic field, and up to 20 tesla within the research arena (Colbert et al., 2008). Other parts of the magnetic resonance machines consist of the bore, the patient table, the gradient magnet, the radio frequency, and the powerful computer (Gould & Edmonds, 2011). The bore is where the patient enters and the magnetic field is created (Gould & Edmonds, 2011). The patient table is where the patient lays (Gould & Edmonds, 2011). The gradient magnets have a range in strength of 180 gauss to 270 gauss (Gould & Edmonds, 2011). The radio frequency waves fit the contour of the body part being imaged and the powerful computer system produces the image (Gould & Edmonds, 2011).

Searching for information on SMF/FMF and their effects on STM was difficult. However, some search terms were helpful and produced important information. The lists of search terms used were *magnetic resonance imaging, side effects caused by magnetic resonance imaging*, *short-term memory*, *NSF, basics of MRI,* and *Dr. Hornak*. Other search terms used were *SMF/FMF, LTM, types of MRI machines,* and *regression analysis*. The sources were obtained digitally, in print version from professional journals, and through books.

History of Imaging Equipment and Magnetic Resonance Imaging

The quest to provide the perfect image of the internal structure has been a challenge that many have chosen to embrace. Throughout the years, Wilhelm Conrad Roentgen achieved the initial advent into this venture in 1895 with the discovery of the X-ray or Roentgen-ray (Assmus, 1995; Woo, 2012). With its original creation, it used a thermionic tube-like structure (Assmus, 2005; Woo, 2012). Roentgen provided us with the first look beneath the skin with a picture of a hand (Assmus, 1995; Woo, 2012). This ignited a desire to produce better imaging of the human body and its parts.

This initial machine provided some with the first images of parts of the human body. The machine did not come without its limitations and drawbacks. The images produced by the machine did not provide any specificity in their contextual definition. The X-ray machine also presented its challenges with respects to the radiation. Any person exposed to the X-ray's produced by the machine would have to absorb radiation (Assmus, 1995; Woo, 2012). Additionally, long-term exposure to radiation has been shown to cause cancer (Assmus, 1995; Woo, 2012).

The ultrasound machine was developed after the X-ray machine. It uses sound waves that are produced by strong electrical pulses to create an image (Woo, 2012). These electrical pulses are then converted into a frequency that ranges from one to 18 MHz (Woo, 2012). This equipment allows the user to use specific frequencies in order to produce the desired image (Woo, 2012). For example, the frequencies are manipulated to image specific parts of one's body. Higher frequencies are used for imaging superficial parts, where lower frequencies penetrate better allowing for better images of the liver and kidney (Woo, 2012).

Next was the computed tomography (CT) scanner. The computed tomography scan uses a computer to manipulate X-rays and these X-rays are used to produce the imaging of the body part desired (Woo, 2012). The image is obtained by using a machine that has a rotating X-ray scanner (Woo, 2012). This machine produces images that are fed into a computer, which performs digital algorithms to produce detailed images of the desired organ (Woo, 2012). The problem with this type of machine is the radiation that it emits into the body (Woo, 2012). These machines have been shown to cause cancer with long-term exposure (Woo, 2012).

Following the CT scanner was the MRI machine. The introduction of magnetic resonance imaging occurred after numerous years of research by Dr. Raymond Damadian and a number of students (Gould & Edmonds, 2011; Hornak, 2011). Others like Felix Bloch and Edward Purcell worked on a similar magnetic resonance phenomenon in 1946 (Thomas, 2009). For their work, they received the Nobel Prize in 1952 (Thomas, 2009). However, Dr. Damadian was the one that in 1971 was able to determine that the nuclear magnetic relaxation times of tissues and tumors differed (Hornak, 2011; Pake, 1993). It was after his determination of this phenomenon that he developed Magnetic Resonance Imaging in 1977 (Gould & Edmonds, 2011; Hornak, 2011). During this same period, others like Peter Mansfield were working on a similar imaging unit called the echo-planar imaging (EPI) technique (Hornak, 2011).

Once Dr. Damadian completed the MRI machine, none of the students agreed to volunteer to enter the machine in order to have it tested. Dr. Damadian became the first person to take an image of himself validating the machine's functionality (Gould & Edmonds, 2011; Hornak, 2011). From this initial discovery, many others joined in their attempt to invent the best imaging machine possible. After this initial test on the machine, new methods to image parts of the body began to surface. Today advancement in MRI imaging has elevated and many different types of images could be taken with the MRI machine.

Types of MRI Machines Used

Since the inception of MRIs, the industry has been using three types of machines. The first type of machine to be used was a permanent magnet machine (Gould & Edmonds, 2011) . This machine uses a permanent magnet in order to create the strong magnetic field that is needed for the imaging (Gould & Edmonds, 2011). The second type of machine is the resistive machine. This machine uses an iron core wrapped with a coil in which electric is passed through (Gould & Edmonds, 2011). When the electric is activated, a magnetic field is created for the production of the images (Gould & Edmonds, 2011). The final type of machine is called the superconductor machine. This machine uses the same concept as the resistive magnet machine with the exception of soaking the coil in liquid helium (Gould & Edmonds, 2011).This design brings the resistance within the coil to zero and makes it more cost effective to operate (Blundell, 2011; Gould & Edmonds, 2011; Hornak, 2011). This machine is common in the field today and requires powering up to activate the magnet.

The first machine, the permanent magnet machine, maintains the magnetic field at all times, but it is too heavy to have within the regular clinical establishment (Gould & Edmonds, 2011). The second machine, the resistive machine, is too expensive to manage because of the power source, usually electric, that is necessary in order to create the strong magnetic field (Gould & Edmonds, 2011). The final type of machine used is the superconductor machine. This type of machine is more customary today. The superconductor MRI is less costly then the resistive magnet and produces the same magnetic potency as that of the other two previously mentioned (Gould & Edmonds, 2011; Hornak, 2011). This MRI machine is less costly to operate due to the absence of resistance within the coil used, requiring less electrical power to operate the machine (Gould & Edmonds, 2011; Hornak, 2011).

Imaging Theory

The theory behind the creation of MRI images stem from the research conducted by scientists interested in determining the best possible method to use in order to produce images of the human body. Scientists like Bloch, Purcell, Lauterbur, Ernst, Mansfield, and Damadian all continued to research various methods that produced quality images (Hornak, 2011). They all were aware that magnetic fields could be used to manipulate the atoms in one’s body. However, they were unsure how to transfer the readings of the magnetic field into an image. It was not until the thought of using radio frequency (RF) signals in order to provide an echo effect within the atoms, that the understanding of the Fourier Transform (a mathematical technique that converts time and frequency domains) surfaced (Hornak, 2011). This is also when the use of this theory became prevalent in the formation of what MRI technology is today (Hornak, 2011).

Producing the Image

In a MRI machine, the imaging is produced by using the water and fat content located in the atoms (Gould & Edmonds, 2011). These hydrogen atoms contain a component that provides small magnetic fields with atoms that spin on their own axis (Gould & Edmonds, 2011; Hornak, 2011). The following is experienced by the atoms in a person’s body when placed under the influence of a magnetic field. When a person is placed in the isocenter of the magnetic field, the hydrogen protons stop spinning on their own axis and line up in two directions evenly (Gould & Edmonds, 2011). Half of the atoms line up towards the person’s head and the other half face the person’s feet (Gould & Edmonds, 2011). Although almost all of the atoms stop spinning, there are a few within the hundreds of millions that continue to spin, which are the ones that are manipulated to provide the imaging seen with MRIs (Gould & Edmonds, 2011).

In order to manipulate the atoms, a patient must first be placed in the MRI machine where the initial stage and magnetic field is created. The second phase provides an RF signal that causes the protons within the hydrogen atoms to spin in a different direction (Hornak, 2011). This is considered the Larmour frequency (Gould & Edmonds, 2011; Hornak, 2011). Once the RF signals are activated a second set of magnets are initiated, the gradient magnets (Gould & Edmonds, 2011). The function of these magnets is to change the strong magnetic field so that a specific location could be imaged and slices could be achieved (Gould & Edmonds, 2011).

Other forms of manipulation of these atoms are used in order to provide images. The spin-echo sequence ID also is used to produce quality images (Hornak, 2011). This sequence uses two pulses of frequency a 90 degree and a 180-degree pulse (Sharma & Lagopoulos, 2010). These pulses provide an echo that is then entered into the MRI's computer (Hornak, 2011). The computer than calculates the different echoes to produce a picture (Hornak, 2011). The picture that is produced is of the same quality as images produced using other theories.

Another type of sequencing that is used to produce images is the inversion recovery sequence. With this sequence, the computer collects data, after two pulses are sent to spin the hydrogen atom (Hornak, 2011).. First, a 180-degree pulse is sent and then a 90-degree pulse follows, before the atom could return to its equilibrium point (Sharma & Lagopoulos, 2010) This causes the atoms to become magnetized (Sharma & Lagopoulos, 2010) It is at this point that a frequency ID (in accordance to the XY plane) is logged and the image is then created (Hornak, 2011).

Shielding

Shielding within the area of the MRI machines is stipulated by standards set by the industry. Although the FDA does make a recommendation, the industry has its own protocols for the installation of MRI machines (Abbott Northwestern Hospital, 2009;

Skopec, 1997). The shielding associated with the installation of MRI machines is more in the area of RF shielding, not magnetic field shielding (Abbott Northwestern Hospital, 2009). Although some sites do require magnetic shielding others, do not. All sites however, are required to adhere to the FDA requirements (Abbott Northwestern Hospital, 2009).

Vibration limitations also present challenges during the installation process. Sites must not be exposed to a large amount of vibration or proper imaging will not be possible. Vibrations could come from various sources. Vibrations could come from elevators, internal movement, and other factors. Vibrations must be eliminated before proper imaging is conducted (Abbott Northwestern Hospital, 2009; Skopec, 1997).

Installation of MRI Machines

Installation of an MRI machine is done in accordance to the original equipment manufacturers and vendor’s recommendations. In order to install the MRI machine it is first placed in a box that is shielded from excessive RF signals, after addressing any vibration concerns. This prevents external radio waves from distorting the created image (Abbott Northwestern Hospital, 2009). The shielding must allow for an environment where a transmission of 100 dB of RF signal attenuation at 100 MHz could be achieved (Abbott Northwestern Hospital, 2009). All systems are different in accordance with their required shielding. Every manufacturer stipulates the recommended shielding for their machine (Abbott Northwestern Hospital, 2009). Professionals within the field have to contact the original equipment manufacturer (OEM) in order to get proper shielding information for their equipment (Abbott Northwestern Hospital, 2009).

All of the shielding is accomplished with the use of various metals like copper, galvanized steel, and aluminum (Abbott Northwestern Hospital, 2009). Before the MRI machine is installed checking for electromagnetic interference (EMI) and vibrations must be conducted. Elevators, subways, and other electrical sources (Abbott Northwestern Hospital, 2009) usually produce these. Once the influences are determined, a box is built for the MRI machine. This box will shield the MRI machine from all of the external influences that could hamper the image.

Some sites use magnetic active compensation systems (MACS). This equipment is designed to address the fluctuations in EMIs. These EMIs exist within the vicinity of the MRI machine. The MACS adjust the image based on the EMI currently affecting the image (Abbott Northwestern Hospital, 2009). If the MACS are not adjusted properly, the image will not be correct.

Five Gauss Zone

Another challenge that has to be considered is the identification of the “5 gauss zone” (Abbott Northwestern Hospital, 2009). This zone is an area around the MRI machine where a five gauss magnetic field exist. This area should be clearly labeled and precautions should be taken in an effort to avoid any unwanted incidents from occurring. Many locations clearly display signs that inform patients and employees that they are within the five gauss area. Some locations use additional precautions by installing a Ferrous Metal Detector System (FMDS). This equipment determines if someone has metals on them that could be drawn into the MRI’s bore (Abbott Northwestern Hospital, 2009).The FMDS serves as a reminder for the individuals that should not be within the area of a magnetic field (Abbott Northwestern Hospital, 2009).

It must be highlighted that shielding requirements have to follow FDA guidelines, which is left to the site coordinators to follow and not FDA monitoring (Abbott Northwestern Hospital, 2009;FDA, 2015 Skopec, 1997). For this study, technologists were queried about the shielding within the confines of their work environment. For those locations where the assessment was held at the technologists work location a physical observation of the zone was made. This helped determine if the proper protocol was followed at the technologist's work locations. Additionally, most of the participants were from facilities that were relatively modern, which required them to follow current FDA guidelines for safety.

Problems with MRI Machines

There had been reports of other dangers that had been associated with the use of the MRI machine's strong magnet. These reports included the attraction to metals that could be drawn into the machine's bore (the opening where the magnetic field is created; Gould & Edmonds, 2011). There had been recorded incidents where items as large as stretchers had been catapulted into the machine (Gould & Edmonds, 2011). These incidents caused damage to the machine and harm to those around it (Gould & Edmonds, 2011). Those that have metal objects inserted into their bodies, like pacemakers and metal screws face another danger (Eitel et al., 2009; Gould & Edmonds, 2011). These individuals are unable to take an MRI due to the risk of having the metal object pulled out of their bodies by the MRI magnet.

Patient Side Effects

Since the inception of MRI, machines many have complained of the side effects associated with the procedure (Ortega et al., 2009; Rota et al., 2010). These complaints led to an interest in researching the effects of magnetic fields. This led to the understanding that the brain could be manipulated with the use of magnetic stimulation (Sligte et al., 2011). It further led to the discovery that patients that take MRIs experience some side effects. It has not provided any information on the technologists that are exposed to the MRI machine. There have been few studies examining the side effects experienced by MRI technologists.

It has been determined that MRIs do cause some side effects to the patients exposed to the strong magnetic field used by the machines (Ortega et al., 2009; Rota et al., 2010). Some of the documented side effects that were experienced by patients were nausea, headaches, and burns. Others side effects were associated with the influence that the dye Gadolinium caused on their bodies (Ortega et al., 2009; Rota et al., 2010). Gadolinium is a dye that is injected directly into the patient’s blood vessels, allowing for detailed images of internal organs and vessels. This dye had been shown to be a challenge to those that suffer from kidney problems, causing the side effects NSF and NFD (Ortega et al., 2009; Rota et al., 2010).

About Nephrogenic Systemic Fibrosis

NSF usually affects a patient’s skin. Patients are known to have suffered from muscle spasms, joint spasms, and joint mobility when they have NSF. This could cause debilitation for those that suffer from NSF. There is also an elevated level of mortality for these patients within 24 months after the appearance of the NSF on their skin. The distance, strength, duration, part of body, type of body, etc. have no bearing on the surfacing of NSF.

NSF is a result of prolong exposure to gadolinium. Gadolinium is a component used in the contrast agent that is used for imaging. Patients that suffer from kidney problems are more likely to experience NSF. These individuals are unable to remove the gadolinium from their bodies in an appropriate amount of time. NSF is only something that patients experience not technologists (Rota et al., 2010). The parts of the body that are usually affected by NSF are the lower limbs, skin, and joints (Rota et al., 2010). Although NSF is confirmed in patients that have taken MRIs, it is not something that technologists are at risk of getting during the procedure.

Short Term Memory

During the early days of psychological study it was believed that memory was unitary in nature and did not contain two separate components in its function (Baddeley, 2004). It was not until many years of study of individuals who suffered various brain injuries, when neuropsychologists began to consider the notion of two separate forms of memory (Baddeley, 2004). Neuropsychologists began to believe that there were two storage areas for any stimuli presented (Baddeley, 2004).This change was seen in the 1970s when the theory of two compartments of storage began to surface (Baddeley, 2004). These two separate units were differentiated based on the time a thought remained within its confines (Baddeley, 2004).

The two designations were named after the length of time a thought was stored. It was believed that a thought, which remained in memory for a long period, was accessed from LTM (Baddeley, 2004). While a thought that was kept active for a short period was considered part of WM or STM (Baddeley, 2004). It was determined that LTM was able to hold an unlimited amount of information. While STM held chunks of information (for small chunks it was seven and for larger chunks it was three; Gobert & Clarkson, 2004). It was also discovered that LTM was permanent in nature and STM was only temporary (only until it was transferred to LTM; Baddeley, 2004).

It was determined that information was stored into LTM once the stimuli passed through STM. The initial stage placed material into the processing system for easy access (STM). When in STM a period of memorization is performed (Baddeley, 2004; Squire, 1992). Once the memorization is completed the stimuli is transferred to LTM (Baddeley, 2004; Squire, 1992). If this process is interrupted in any manner, the material will never make it to LTM and will be lost (Baddeley, 2004).

Other discoveries led to the understanding that material with a semantic meaning has a better chance of making it into LTM (Baddeley, 2004). Baddeley (2004) pointed out how semantic processing has a stronger chance of being retained than one that does not receive this type of attention. Baddeley confirmed that stimuli, which could be linked, to personal experiences had a better chance of making it to LTM. Baddeley was able to confirm the importance of various types of memory and furthered the understanding that separate units of storage are used to process information. For example, explicit or implicit memories are elements of our memory system that use various areas of the brain for their function (the hippocampus, temporal lobes, and frontal lobes) (Baddeley, 2004). Baddeley indicated that it was through the linking of three regions (the hippocampus, temporal lobes, and frontal lobes) that a person is able to process explicit memory. This particular connection is called the Papez Circuit (Baddeley, 2004; Domesick, 1969).

The importance of the Papez Circuit is highlighted in the stages associated with storing material within the memory systems. The process of encoding, storing, and retrieving material integrate all aspects of these three regions. If any one of the three areas (hippocampus, temporal lobes, or frontal lobes) is affected, it could be assumed that the memory system will be hampered (Squire, 2004). A part of the Papez Circuit the hippocampus has been shown in studies to be associated in memory. Many animal and human studies have isolated changes in the hippocampus and memory when magnetic fields/pulses were used to influence the hippocampus (Colbert et al., 2008; Sligte et al., 2011; Whissell et al., 2009).

This was shown to be the case with research conducted on rats, where changes within the animal's hippocampus produced changes in the animal's memory system (Whissell et al., 2009). In their study, Whissell et al. (2009) exposed prenatal rats to four intensities of complex magnetic fields for 22 days and again after 90 days, the rats were tested. It was determined that this exposure affected the learning ability of the rats. It was also discovered that the complex magnetic field exposure altered cell densities within the hippocampus of the rats. This caused problems in the rat's ability to store material in memory.

A Study on Short Term Memory

Sligte et al. (2011) conducted a study to determine if visual short-term memory (VSTM) is separate from visual working memory. In an effort to test this hypothesis, a magnetic stimulation was used with the assistance of an MRI machine (Sligte et al., 2011). Stimulation to the right dorsal lateral pre-frontal cortex (DLPFC) was provided by the use of a 3.5 T MagStim Rapid Stimulator and a figure-of-eight coil. The transcranial magnetic stimulation (TMS) was provided at a level equivalent to 110% of the resting motor threshold. This led to results indicating that fragile VSTM is not a form of visual working memory (Sligte et al., 2011).

This particular study does indicate that the memory system could be affected with the use of a magnetic field. Although there are similarities between Sligte et al. (2011) and this study, there are clear differences. This study was interested in determining if the continuous existence of a residual magnetic field within an area causes concerns. This study did not look into an induced stimulation that was present for only a specified duration of time (Sligte et al., 2011). This particular study looking into the STM of MRI technologists was not able to manipulate the magnetic field and was not a true experiment.

Animal Studies

Studies with Negative Results

Within the area of animal studies, the obvious influence magnetic fields or pulses play on the changes within their cerebral cortex and specifically the areas of interest within the context of this paper are confirmed. These areas consisted of the temporal lobes, the frontal lobes, and the hippocampus (Baddeley, 2004; Squire, 1992). Various animal studies have examined the influence magnetic fields have on these areas. These studies indicated that magnetic fields or magnetic pulses have affected at least one of these areas, the hippocampus (Delparte & Persinger, 2007; McKay & Persinger, 2005; St-Pierre et al., 2007; Whissell et al., 2009). In one study, magnetic fields caused atrophy of this area (Whissell et al., 2009).

Delparte and Persinger (2007) examined whether theta burst magnetic field could impair memory consolidation. In their study fourteen male Wister rats of ages, or 5 months were used. The rats were prevented from eating before being placed within the experimental environment where food was provided. Within the confines of this conditioned place preference (CPP), a continuous magnetic field was present. The rats were also exposed to pulses of magnetic potency of .20mT and 1.71mT with Metex 3800 multimeter and a magnetic sensor probe. They were then tested for memory by placing them in the CPP where food was in the far corner. Researchers then attempted to determine if the rats could remember the CPP environment.

The results indicated that the magnetic pulses did have a significant effect on the rat’s memory. An analysis of variance was used to determine if a difference in the amount of time the rats spent in the CPP environment was significant with respects to the magnetic field pulses. This analysis indicated that the influence of the magnetic pulses was relevant in impairing the CPP results. The results presented a two-way analyses of variance, Post hoc Tukey’s (< .05) for between subject variance and paired t-tests (< .05). The results showed a significant interaction between chambers and treatments [F (3, 12)

= 10.57; $p < .01$; eta 2 = 80%] (Delparte & Persinger, 2007). The study also concluded that short-term exposure of a theta burst magnetic field, of 15-minute intervals, could lead to deficits in consolidation of CPP results (Delparte & Persinger, 2007).

Another study indicated that exposure to a magnetic field caused a significant change in the behavior of four Wistar male rats in the areas of ambulation, defecation, and grooming (St-Pierre, et al., 2007). During this study, the four Wistar rats were exposed to a magnetic field of between 0.5 and 1 microT, for 15 minutes before testing them for 2 minutes in an open field. The rats were tested two at a time and once completed with the test they were placed in their chamber. The results of the four way analyses of variance indicated a difference in ambulation.

In yet another study, Whissell et al., (2009) found that rats which were exposed to CMF during prenatal or perinatal periods did show impairments within their hippocampus. Whissell et al. (2009) exposed rats to .05Hz of rotating magnetic field within the MilliTesla range. They found that male rats were affected with reduced cell density. When the CMF was increased from 10nT to 50 nT range there were dramatic changes to the rat's hippocampus. They concluded that LTP of CMF patterns does lead to hippocampus structural changes. Further, they found that the limbic system in general is sensitive to magnetic fields (Whissell et al., 2009).

In this same study, Whissell et al. (2009) conducted a force-swim test on the rats that were exposed to the same magnetic field levels of 5nT to 1 mT for a duration of 10-second intervals. This forced swim was 15 minutes in duration every second day, for four consecutive weeks. A cylinder containing 75cm of water was used. The water was kept at a temperature of 25 degrees Celsius. The rats climbing, immobility, and swimming were tested. After testing it was concluded that the rats were significantly affected with respects to their performance in various swimming task, This significant difference points in the direction of an influential difference in the areas which affect memory and/or learning, like that of the hippocampus. Within the hippocampus four regions, were examined, the Cornu Ammonis (CA) fields 1 through (hilas regions). The results indicated a statistically significant difference in cell density in the CA1 regions (Whissell et al., 2009). This was also shown in monkey experiments where monkeys with lesions to the CA1 region of the hippocampus led to impairments in memory (Squire, 1992; Whissell et al., 2009).

Studies with Positive Results

There were also positive uses for magnetic fields demonstrated in some animal studies. McKay and Persinger (2005) pointed out that CMF could be used to guide blind rats towards food quicker as compared to not having the CMF present. McKay and Persinger (2005) concluded that the rat’s behaviors could be changed with the use of magnetic fields. In their study, 44 male Wistar rats were used. The rats faced deprivation of food over a period of time in an effort to prepare them for the experiment. For the study, a 60cm wide maze was used and the intensity of five gauss was present within the confines of the structural setup. The rats were found to have lower times when a magnetic field was present as compared to when it was absent.

Human Studies

Human studies have also indicated both positive and negative consequences from having magnetic fields present. One study was able to show that magnetic fields/burst pulses could be used to provide relief for mental disorders (Rohan et al., 2004). In another study, St-Pierre and Persinger (2006) determined that the hippocampus and temporal lobes are involved with the memory structure. In their study, they were able to influence the temporal lobes with a magnetic field. This led to reactions from the individuals that included memory deficits and seeing phantom visions or “Sentient Being” (Meli & Persinger, 2009; St-Pierre & Persinger, 2006).

In other studies, the hippocampus was isolated as being the cause of the circumscribed memory impairment in four patients, leading to selective memory disorder (Squire, 1992). The hippocampus atrophied substantially, to 57% of its normal size (Squire, 1992). These discoveries were further strengthened by additional human studies. These additional studies used burst of magnetic fields to the temporal lobe region. The results indicated that magnetic fields have an influence on how a person felt; with increased senses of dizziness, sensed presence, “ego-alien thoughts, and feeling of detachment from the body” (Meli & Persinger, 2009, p.68).

The Area of the Brain Responsible for Memory

Baddeley (2004) provided a historical demonstration on the evolution of memory from a unitary ideology into a two segmented storage system. These two segments consist of STM and LTM. Miller, Watson, and Strayer (2012) extended this view on memory storage facilities by inserting a temporary store WM. Baddeley articulated the

Baddeley and Hitch model of working memory. This model consisted of a central executive processing system, visuospatial sketchpad, and the phonological loop. Baddeley identified the main components of memory as being the hippocampus, frontal lobes, and temporal lobes.

The premise of this study led to a number of questions in attempting to determine the influence magnetic fields have on STM. One of the main questions focused on determining what area of the brain is responsible for STM. This helped in clarifying if residual magnetic fields either directly or indirectly influence the area of the brain responsible for STM. In response to this question, the literature points to the responsible areas that control memory being embedded within the limbic system. This system consists of the amygdala, hippocampus, cingulated cortex, fornix, septum, and mammillary body (known to be part of the medial temporal lobes; Pinel, 2006, pp.69-72). Of these, the location of most interest with respects to this paper was that of the hippocampus (Squire, 1992; St-Pierre & Persinger, 2006.

The hippocampus has been shown to be responsible for the creation of memory (Squire, 1992). Some researchers refer to it as the glue that unites all the components of the neocortex that represent the memory (Squire, 1992). Additionally, the cerebral cortex is strongly connected to the hippocampus and other components of the medial temporal lobes (McKay & Persinger, 2007). Squire (1992) pointed out that the region of the cerebral cortex identified as the fimbria, dentate, dentate gyrus, hippocampus, proper, and the subiculum showed marked atrophies with individuals having memory impairments.

These studies strengthened my conclusion in isolating the hippocampus as the part of the brain mainly responsible for the formation of memory.

The Hippocampus and Short Term Memory

The discoveries that led to the association of the hippocampus to STM were mainly due to a number of studies on individuals with amnesia. Some of the most famous cases consisted of two participants R. B. and H. M. R. B. was a patient that became amnesic in 1978 after suffering from an ischemic event (Squire, 1992). After the ischemic episode, R. B. was extensively tested and out of these test it was discovered that he had suffered severe memory impairment. It was not until after his death and an examination of his brain were conducted, that scientist discovered the cause of his memory impairment. His memory challenges were isolated to a lesion in the CA1 region of the hippocampus (Squire, 1992).

The study conducted on H. M. provided further confirmation of the hippocampus' involvement in memory. H. M. suffered from seizures and doctors had part of his medial temporal lobe structure removed in addition to his hippocampus (Eichenbaum, 2001; Squire, 1992). After surgery, H. M. suffered severe memory impairment. This case is familiar to many in psychology because H. M. was the most studied human amnesic patient. Studies conducted on H. M. provided confirmation that the region of the brain responsible for memory as being the hippocampus (Eichenbaum, 2001; Squire, 1992). The surgical procedure performed on H. M. was performed on monkeys in a 1978 study. The monkeys had a large portion of their temporal lobes removed. The monkeys were confirmed to have deficits in their memory (Squire, 1992). These impairments were the same as experienced by H. M. In further confirmation of this discovery, researchers conducted further animal studies (with rats and monkeys) and human studies and concluded that the hippocampus is essential for memory.

In another experiment, St-Pierre and Persinger (2006) confirmed that the use of a magnetic field applied to the temporal lobe region could elicit a sensed presence. In their study, 19 experiments were conducted with the use of 407 subjects, ages 17 to 55 years old. The subjects were first-year university students who volunteered with the agreement that they would receive two extra points on their final grade. The subjects were blindfolded and low burst of voltage were delivered through solenoids in the helmets that were wore. The voltage was graded by using a point system from 0 and 255; where below 127 = negative polarity was delivered and above 127 = positive polarity was delivered. These intensities were delivered for a period lasting 1 ms or 3 ms with a port latency of about 100 micro-s. to their temporal lobes. The results of this research confirmed that a sensed presence could be produced under laboratory conditions, when the temporal lobes are exposed to a magnetic field (particularly the right temporal lobe; St-Pierre & Persinger, 2006).

Summary

Considering the various animal studies many conclusions could be reached. First, animal studies have already documented the influence that magnetic fields (even at low levels) have on the brain of animals. Secondly, animal studies have isolated specific areas of the animal’s cortical structures as areas that were manipulated by magnetic fields, resulting in a reduction in some memory induced behaviors. Third, permanent structural changes within the memory region of the brain (the hippocampus and the cortical region) could occur when the regions are exposed to a magnetic field (Delparte & Persinger, 2007; McKay & Persinger, 2005; Squire, 1992; St-Pierre et al., 2007; Tsang, et al., 2009). Fourth, magnetic fields could be used for positive purposes (animal studies have shown that magnetic fields did influence performance in memory task).

These discoveries in animal research could be extended to human research. In one human study burst of magnetic fields to the temporal lobe region were shown to have an influence on various elements of the person's behavior. For example, exposure to a magnetic field influenced how the person felt with increased senses of dizziness, sensed presence, "ego-alien thoughts," and feelings of detachment from the body (Meli & Persinger, 2009, p.68). Other human studies pointed out a 43% reduction in the hippocampus of four patients that suffered from circumscribed memory impairment, leading to selective memory disorder (Squire, 1992). These discoveries lead to the conclusion that the hippocampus is associated with memory in both animal and humans. The combination of these findings suggest that magnetic fields which have been shown to influence the hippocampus in studies using nonhumans may also affect STM which is associated with the hippocampus (Baddeley, 2004; Squire, 1992).

Within the confines of human studies, the literature presented has shown that magnetic fields do have an influence on the activities of the temporal lobes and the hippocampus, among other components of the memory structure (Meli & Persinger, 2009; Squire, 1992; St-Pierre & Persinger, 2006. Well-known studies like that of H. M. (with temporal lobe lesions) and R. B. (with a lesion in the hippocampus, region CA1) provided us with a further understanding of the functions of the memory structure (Pinel, 2006, pp. 261-262; Squire, 1992). These studies draw a direct link between memory and the regions of the brain. The studies confirm that at least two regions are directly involved with memory. These two areas are the temporal lobes and the hippocampus. These findings suggest that these two areas may also affect STM.

Chapter 3: Research Method

Introduction

In this chapter, I present the research methods linked to this study. I provide a description of the study's design, data analyses, and ethical considerations. I also provide support for the reasoning behind the selection of the particular design for the study. Justification for the selection of a particular sample size is also presented and a full descriptive overview of the instrumentation used for the study is given. In the chapter, I also provide the data analyses that pertain to the data collected during the research study.

The purpose of this study was to determine if there was a significant difference between the STM of MRI technologists and non-MRI technologists. The premise for this quest was embedded in the notion that magnetic fields had been identified as being influential in areas of memory structure. Since MRI technologists work around magnetic fields they serve as ideal participants for this study (Colbert et al., 2008). In the next section, I look into all of the elements associated with conducting this study. These elements are inclusive of the methodology, setting, sample size, test tool, and statistical analyses used.

Research Design and Approach

This study looked into determining whether or not there exists a relationship between being exposed to a residual magnetic field and the loss of STM. The participants in this study were limited to MRI technologists and non-MRI technologists. Any MRI technologists and non-MRI technologists that have a long history of drinking alcohol excessively were not included as part of this study. Only data from technologists and non-technologists within the New York/New Jersey metropolitan area and the New Hampshire/Maine area were used. This limited the pool from which the participants were selected.

The study evaluated whether there exist a difference in STM between the average population's STM scaled scores when compared to MRI technologists' scaled scores. This was done through data gathered from the use of a test tool, the RBMT-3. The data were then taken and statistical analyses were performed. The statistical analyses used for this study were both the ANOVA and regression analysis. The ANOVA analysis was used to determine if a statistically significant difference existed between the scaled scores of both groups. The ANOVA provided for the analyses of the mean of the covariate on each experimental variance between the two groups and their health responses and technologists work environment.

In order to eliminate the memory degradation concern associated with age only, the scaled scores of both groups were used. The scaled scores were calculated using the RBMT-3 assessment tool. The tool allows for the conversion of raw scores into scale scores, which account for age. The RBMT-3 has a conversion chart that allows researchers to use a participant's age and raw score and convert it into a scaled score. This was done for all subsections of the assessment.

Setting and Sample

Participants

The participants for this study were selected from a convenience sample of MRI technologists and non-MRI technologists from the New York/New Jersey metro area and the New Hampshire/Maine area. The MRI technologists were solicited from an MRI technologist's society, the American Society of Radiologic Technologists (ASRT), or from direct solicitation through the MRI facilities. The MRI technologists were selected based on the following: (a) they were the population that worked with MRI machines, (b) they worked within the NY/NJ metropolitan area and the New Hampshire/Maine area, and (c) they agreed to sign a consent form allowing the use of the data gathered from their assessment. A copy of the permission solicitation could be seen on Appendix A. With the control group, a posting was displayed on the local community boards. The Walden IRB approval number was 10-07-14-0056843.

Procedures

A power of 80% was used along with an effect size of .20 and a *P* of .05 in the analyses. This revealed that a two tail test at $p < .05$ required a sample size estimated to be 40 participants per group (Lipsey & Wilson, 1993). Written information providing specifics about the study and an informed consent was provided to all participants. The informed consent provided the participants with guidelines for participation in the study. These guidelines were inclusive of the following background information on the study, what the protocols of the study were, what procedures the participants needed to follow, confidentiality for participants, ethical concerns, and voluntary participation requirements.

The initial stage included communication with the society requesting their cooperation in soliciting participants. Once cooperation was confirmed, a description of the study was distributed directly to the MRI technologists. A copy of the consent form can be seen in Appendix B. As part of the procedure, an e-mail was sent for those that had questions regarding the consent or any other elements of the study. Individuals that indicated interest in participating in the study provided their contact information, which included their name and phone number. These individuals were contacted and a date, time, and location were selected where the assessment would be given.

The assessment was given in a conference room at the local library where the participant resided or at an agreed upon location. No external distractions were present. A letter requesting permission for the use of such a room is included in Appendix D. The testing location was changed based on the approval of personnel and/or a participant's ability to make it to the selected location. When the location was changed, the new meeting location was selected with the approval of the participant.

As part of the process, a questionnaire was presented to the participant. As part of the questionnaire, some specific information was requested. The questions included the length of time they worked with MRI machines, were they exposed to other test equipment, weekly hours they worked throughout the years (on average, with MRI machines), age, gender, and educational background. After the assessment was completed, the questionnaire was examined. Based on the results of the questionnaire examination, I determined whether or not participants qualified to be included in the study.

Instrumentation

Demographic

A demographic questionnaire inquired basic information on the technologists. This information included their age, gender, education, ethnicity, estimated hours worked with MRI machines, and location of employment. The same questionnaire was given to the control group. The control group's questionnaire had minor changes that excluded any questions that were related to MRI machines. These questions were employment questions relating to being employed as an MRI technologist. A copy of both questionnaires can be seen in Appendix C (for MRI technologists and for MRI non-technologists).

Rivermead Behavioral Memory Test-3

The RBMT-3 is an effective memory test tool that allows for the testing of memory as it pertains to its use for everyday functions (Wilson et al., 2012). The RBMT-3 provides for a platform that consists of 14 tasks that resemble everyday memory situations (Wilson et al., 2012). The areas that are covered consist of questions associated with testing the various sectors of the brain's memory system (Wilson et al., 2012). These questions consisted of a participant remembering a person's first and last name, recalling a hidden belonging, appointment recall, face recognition, short story recollection, picture recall, remembering a new route, message deliverance, and answering orientation questions. The subsections are designed to test the various areas of the memory: verbal memory, visual memory, spatial memory, prospective memory, orien/date, and new learning (Wilson et al., 2012).

Test Reliability/Test-Retest Reliability.

According to the RBMT-3 manual, the inter rater reliability for the RBMT-3 was confirmed with two raters being in agreement of the scoring rules (Wilson et al., 2012). Test-retest scores were .78 and .85 for 118 patients tested twice (Wilson et al., 2012). As could be expected, performance for the second test was slightly better because of familiarity (Wilson et al., 2012). The difference between the form and correlation between Forms A, B, and C was good and at least .80 correlations between A and D (Wilson et al., 2012). The final conclusion indicated that the RBMT-3 is a good tool to test memory of everyday actions or activities (Wilson et al., 2012).

The test-retest reliability was shown to present a stability of .78 and .85 with the tool administered to 118 patients twice (Wilson et al., 2012). Validity was confirmed with the use of brain-damaged patients (Wilson et al., 2012). A total of 113 men and 63 women (mean age of 44.40) were used (Wilson et al., 2012). Of the participants, 60 suffered head injury, 34 suffered from a left CVA, 42 from a right CVA, 13 suffered a subarachnoid hemorrhage, and 27 other injuries (Wilson et al., 2012). In the control group, 118 subjects were used with age between 16 and 69 (mean age of 41.17) and mean IQ of 106 (Wilson et al., 2012).

The test-retest reliability/validity was seen as, for screening V =.78 and for profile score V =.85. (Wilson et al., 2012). Further, validity was determined in the confirmation that RBMT-3 was able to access memory functions that are involved in other components of memory. Therapists gave the assessment high rating with respects to central nervous system dysfunctions (Wilson et al., 2012). To assist in the better identification of the test with the participant, a coding system was used. This coding system links each test with the designated participant.

For the preteen population very little info exists and no table is provided. This does not present a concern for this study because this population was not tested. The RBMT-3 is one of only a few tests that could be used to evaluate everyday memory functions and everyday living situations. The test is especially effective in evaluating individuals with brain dysfunctions (Wilson et al., 2012). The RBMT-3 allows for the testing of their everyday situations or everyday memory functions (Wilson et al., 2012).

The RBMT-3 tries to determine with the use of an "ecological validity" approach, the memory skills that are appropriate for everyday life (Wilson et al., 2012). Some of the practical elements that the test looks into are, whether "someone borrows something, remembering everyday information. Other elements are remembering to get back to the person, remembering what the bell ringing means, orientation in time and space, and remembering or recognizing people, among other everyday actions" (Wilson et al., 2012, p. 1). Once testing is completed, it is expected that all areas of the person's memory system has been assess or tested.

In comparison to other memory tools, like the Wechsler Memory Test and the Recognition Memory Test, the user of RBMT-3 better understands which types of everyday problems they may have (Wilson et al., 2012). Unlike other tests, the RBMT-3 could provide direction and detect the severity of the memory problem (Wilson et al., 2012). There are various versions of the RBMT-3. One version is used for children between of ages 5-10 years old with brain damage (Wilson et al., 2012). The RBMT-3 is a good test to use for screening any possible memory problems and if specificity of the memory problems are required (Wilson et al., 2012).

For this study, none of the participants experienced brain damage. Therefore, the results did not have to be scrutinized differently. In order to administer the assessment specific training and for practice in administering the RBMT-3, I took the test. A trained licensed counselor that had experience administering memory tests also guided me. Once the assessment was completed by the participants, no further tests were given.

Analyses

This study employed a quasi-experimental design. This design is limited in its structural design. For example, due to the nature of the design the independent variable, the magnetic field, could not be manipulated in humans because of ethical concerns (the possibility of harming the participants).Therefore, intact groups were used that examined those with a history of exposure to magnetic fields versus those without this history of exposure. The quasi-experimental design is consistent with this process. One of the limitations of the quasi-experimental design is that cause cannot be inferred, as there is no random assignment to the independent variable groups. This presents the possibility of confounding variables. However, it should not be concluded that the data gathered from this study is not consequential and is not indicative of technologists being exposed to SMF/FMFs.

The instrument used (RBMT-3) for measurement of memory is designed for memory test that are associated with actions that an individual would perform on a normal basis, based on everyday activities. This allowed for the analyses of a variable that the controlled population was not exposed to (residual magnetic fields) and how normal every day function for technologists was affected by this variable. The analyses provided for an evaluation of significant difference between two groups with respects to STM. The research questions and hypotheses were reflective of this analysis. The research questions and hypotheses are repeated to allow for further review.

The software that was used to complete the statistical analyses was the SPSS software. This software was well established within the psychological community. It was considered a powerful tool in statistical analyses. It provided the material necessary for the presentation within the fourth chapter. The tables that are part of Appendix E and F are result gotten using SPSS.

Research Questions and Hypotheses

Research Question #1. What was the difference between the STM of MRI technologists and non-MRI technologists'?

Directional Hypothesis #1 It was expected that MRI technologists that worked within the confines of MRI machines displayed differences in STM as measured by the RBMT-3 when compared to non-MRI technologists.

Null Hypothesis #1 It was expected that MRI technologists that worked within the confines of MRI machines did not display differences in STM as measured by the RBMT-3when compared to non-MRI technologists.

Research Question #2 What was the difference between the STM of MRI technologists versus non-MRI technologists when accounting for all demographic variables?

Directional Hypothesis #2 It was expected that MRI technologists' STM would differ when compared to non-MRI technologists when including demographic variables.

Null Hypothesis #2 It was expected that MRI technologists' STM would not differ when compared to non-MRI technologists when including demographic variables.

Research Question #3 How much variance in STM is explained by the MRI technologists' status after accounting for demographic variables?

Directional Hypothesis #3: It is expected that MRI technologists' work status variables will explain a significant variance in STM after accounting for demographic variables .

Directional Hypothesis #3: It is expected that MRI technologists' work status variables will not explain a significant variance in STM after accounting for demographic variables .

Null Hypothesis #3: It is expected that MRI technologists' work status variables will not explain a significant variance in STM after accounting for demographic variables .

Ethical Considerations

Careful consideration was given to the participants of this study concerning the nature of the study. An informed consent was given to all participants of this study. As part of the informed consent, participants were made aware that they had the ability to stop the testing as it was ongoing and refuse to be included as part of the results. They were assured that their information was and would be kept confidential. They were made aware that their participation in the study was voluntary and of the risks that were associated with the study. All of the benefits were given to the participants along with the researcher's contact information. The participants were made aware that I could be contacted in the event they had any questions.

As clearly stated in the informed consent (Appendix B), the records associated with the study were protected. I am the only party that is privy to the records. The consent forms, copy of the RBMT-3 forms, and any pertinent material associated with this research study were kept in my home. The material was kept in a locked safe made of steel that had a combination. I only know the combination code.

Following the completion of the study, all material will be placed in a safe deposit box with key accessibility at the local bank. The bank where the box will be located is Valley National Bank. I will be the only one to have access to the safe deposit box. The coding for the material was done in a form that will display a letter and number system. The letters refer to the participants' names and whether they are MRI technologists or non-MRI technologists and the numbers refer to the participant tracking position and age.

The data will be discarded after 5 years, which is within the ethically required duration necessary for storing data of this research magnitude. The participants of this study had all the rights to withdraw from the study without any consequences. The study had no direct connection with the participant's employment and was not influenced by the participant's employer. To my knowledge, there were no physical ramifications associated with this study; however, there could have been emotional negative consequences that surfaced within the administration of the study. For example, if a participant discovered that their STM had dissipated with time, the emotional reaction from the participant was unknown and could have been one that was negative in nature. The acknowledgement of receiving informed consent was defined as having received signed confirmation and understanding of the consent form and its contents.

Summary

Chapter 3 looked into the various components that were part of the design of this study. The approach, setting, and sample size was evaluated. The procedure used in the study along with the instrumentation was discussed. A thorough look into the RBMT-3 tool used for the collection of data was explored as well as the validity of the tool. The presentation of the research questions and hypotheses were presented again for convenience. Finally, the ethical considerations of the study were expressed. In chapter 4 the results of the study will be discussed in detail, along with the demographics used in the study.

Chapter 4: Results

Introduction

The goal of this study was to examine potential group differences in STM among those with long-term exposure to magnetic fields compared to those without this history of exposure. Specifically, the goal of this study was determine quantitatively if there existed a significant difference between the STM of MRI technologists versus non-MRI technologists. This study used a quasi-experimental design in the investigation of the MRI technologists' and non-MRI technologists' STM. In order to accomplish the goal of the study, a RBMT-3 was used to gather data for the analysis stage. The SPSS statistical software was used to analyze the data. The analyses consisted of an ANOVA and regression analyses.

The study was structured taking into account the magnetic fields that exist around MRI machines, SMF and FMF, and the possible effects of those exposed to these fields. These fields are those that are present within the vicinity of the MRI machine. Individuals that are MRI technologists are exposed to these magnetic fields during their work tour. The fields are defined according to the distance one is from the MRI machine. The field that is present when one is close to the MRI machine is the SMF. The field that is present when one is further away from the MRI machine is the FMF.

In this chapter, I provide an explanation of all the elements associated with the study and for the findings of this study. I also provide for the demographics associated with the study and further provide for an understanding of the various analyses used to determine the results of this study. I conclude the chapter with the analysis of the hypotheses associated with the study and suggestions for future studies.

The Four Analyses Used

In this chapter, I provide a summary of the results associated with the statistical analysis in four areas. The first analysis looked into whether or not there existed a significant difference in the STM scores of the MRI technologists versus the memory scores of non-MRI technologists for the total STM score (sum of scaled scores). The second analysis looked into the group differences for each subsection of STM. These analyses were done using an ANOVA. The third and fourth analyses used regression analyses to obtain the results. These two analyses were used to determine if a significant difference in the variance existed in the questionnaire questions for all of the participants. They were also used to determine if a significant variance existed within the MRI group alone. With the third analysis, the health questions were reviewed with all of the demographics. In the fourth analysis, only the questions that pertain to the MRI technologists were reviewed and analyzed. These included questions that were related to the technologists' work environment, type of equipment exposed to, and amount of hours that the technologists worked weekly.

Sample Demographics

Over a number of weeks, solicitation of participants was conducted via the use of numerous community boards and direct mailings. Due to these efforts, 82 individuals agreed to be participants in the study. Informed consents were provided to these participants either through direct e-mailing, at the time of testing, or both. Out of the 82 participants, all signed an informed consent before any testing was conducted and none of the participants withdrew from the study. Therefore, out of the 82 participants 82 (100%) signed the informed consent and successfully completed the assessment. Of these 82 participants 33 (40.25%) were males and 49 (59.75%) were females. Out of the 82 participants, 41 were part of the MRI technologists' group and 41 were part of the control group (non-MRI technologists' group). Table 1 and Table 2 provide for the characteristics of the study.

Table 1

Sample Demographics of MRI technologists

Age Bracket and Educational Background	*n*	%
18-30	3	7.3
31-40	5	12.2
41-50	9	22
51-60	14	34.1
61-100	10	24.4
High School	1	2.4
Associate's	15	36.6
Bachelor's	23	56.1
Master's	2	4.9
Doctorate	0	0

Table 2

Sample Demographics of non-MRI technologists

Age Bracket and Educational Background	n	%
18-30	21	51.2
31-40	3	7.3
41-50	9	22
51-60	5	12.2
61-100	3	7.3
High School	16	39.1
Associate’s	18	43.9
Bachelor’s	4	9.7
Master’s	2	4.9
Doctorate	1	2.4

Of the overall sample size (*N* = 82), more than one half (61%) of the participants were under 50 years old (for participants between the ages of 18-50 years old) and more than one half (63.4%) of those were female participants. Of all the female participants in both groups, over 30% (31.7%) were under the age of 50. The fewest number of participants in the overall sample size (*N* = 82) were within the age group of 31-40 years old (9.8%). For both groups, the average age differed with MRI technologists having an average age of 50.9 year old. The non-MRI technologists had an average age of 36.27 years old.

The population base had a high level of education. Most of the participants had at least an Associate’s degree (40.2%) and close to 80% (79.26%) received an Associate’s or higher degree. The study sample was diverse in the participant’s age and educational background. Of the study groups consisting of only MRI technologists participants (*n* = 41), more than one-half were female (65.85%). The largest sample size for the MRI technologists was seen in the 51-60 age groups (34.1%) and the fewest were seen in the 18-30 age group (7.3%). Most of the MRI technologist participants were highly educated, with 56.1% completing a Bachelor's degree and 4.9% obtaining a Master's degree. Of all the MRI technologists, 95.23% completed at least an Associate's degree. More than one half worked as MRI technologists for over 15 years (56%).

Test of Memory and Scaling of Scores

The scaled scores were used for the subsequent analyses. All sets of scaled scores for each type of memory were analyzed. This analysis included the individual scaled scores and the sum of scaled scores. In order to obtain a scale score, a conversion of the raw score had to be conducted. This conversion allowed for the accounting of the age of all the participants. This conversion was done for every subsection of the assessment and the results are included within the contents of this chapter.

In accordance with the protocol for the RBMT-3, every subsection of the assessment was administered. The various subsections are representative of verbal memory, visual memory, spatial memory, prospective memory, orien/date memory, and new learning memory. Once each section was completed, a raw score was calculated for each section and the summation of all of the subsections provided for a sum of raw scores. The RBMT-3 provided for the scaling of the raw scores in order to account for age. The flexibility of the RBMT-3 allowed for the calculation of each individual subsection, as well as the summation of all the scaled scores for all the subsections (Efklides et al., 2002).This scaling was completed with the use of a chart included in the

RBMT-3 test tool. A calculation of both the raw scores and the scaled scores was completed.

Hypothesis 1

The first hypothesis predicted that MRI technologists would display changes in STM when compared to non-MRI technologists. In order to test this hypothesis an ANOVA analysis was performed. This allowed for the determination of whether a significant difference existed between the group that was exposed to the MRI environment and a control group. The analysis provided mixed results indicating no significant difference between the STM of MRI technologists versus that of the control group's sum of scaled scores (SSS) = F (1, 80) =3.061, p = .084 (M = 128.29, SD = 12.422; M = 122.49, SD = 17.235;values of the ANOVA are presented in Appendix E). However, the results did demonstrate a significant difference in two of the 14 subsections. These sections are associated with prospective memory, Prospective Memory 9 (PM9) = F (1, 80) =10.44, p = .002 and Prospective Memory 19 (PM19) = F (1, 80) =18.522, p = .000 (values of these analyses are presented in Appendix E).

Hypothesis 2

Hypothesis 2 predicted that the level of change within MRI technologist's STM would be significant when considering the various age ranges, genders, and educational levels. In order to examine this, a regression analysis was used. Based on the regression analysis, a determination was reached indicating no significant variance in the STM of MRI technologists versus that of non-MRI technologists, H2 = F (5, 76) = 4.035, p = .003 with R^2 = .210. The analysis did indicated a significant difference in Height B = 2.208, t

(80) = 3.247, p <.002. and Gender B = 16.491, t (80) = 3.728, p = .000. Values of the regression analysis are presented in Appendix F.

The third statistical measurement, regression analysis, was used in order to look into any significant health concerns that may be present in the MRI technologists versus non-MRI technologists. The results indicated no significant difference between both groups (the results are presented in Appendix F). It should be noted that the results for health concerns regarding thyroid problems were very close to showing a significant difference. For this reason it is suggested that further research be conducted, which will include a larger population size.

The fourth analysis used a regression analysis. This analysis looked into whether there was a significant variance in the results of the MRI technologist’s sum of scaled scores. Various variables were considered in this analysis, such as the technologist’s years of employment, weekly hours worked, years working with MRI machines, and working on other machines. The results did not indicate a significant variance when those variables are taken into account F (7, 74) = 1.280, p = 272 with R^2 = .108. The results of the regression analysis can be seen in Appendix F.

Results of Analyses

The analyses produced mixed results showing no significant difference between MRI technologists and non-MRI technologists when it came to the overall memory scores of both groups (SSS). The results did indicate a significant difference in prospective memory in subsections of the RBMT-3 (PM9 and PM19). The findings also indicated that if age is taken into account, a significant difference is not present in the overall memory score (SSS) of both groups. Other areas, which were reviewed statistically, looked into the difference in health questions between both groups and a final analysis was done on the MRI technologists alone. This final analysis helped determine if any of their results were influenced by various variables associated with their job (i.e., hours worked weekly, years of employment, etc.)

It must be noted that conflicting results have surfaced in various studies when viewing PM in older adults. In a study conducted by Henry, MacLeod, Phillip, and Crawford (2004), it was discovered that older participants had results that were lower than younger participants when it came to their PM. These results were based on using participants that were 60 years old and older for the older group (age: *M* = 70.7) and those below 60 for the younger group (age: *M* = 22.2). Another study by Niedzʼwienʼska, Janik, & Jarczynʼska (2013) found that older participants (age: *M* = 68.33) performed better in PM when importance was placed on the activity they wanted to remember versus younger participants (age: *M* = 21.70). These findings help in the understanding of the current results in this study.

This study found a significant difference in the PM of MRI-technologists versus non-MRI technologists. In looking at the demographics of this study, the average age for the non-MRI technologists over 60 (age: *M* = 81) was significantly higher than that for MRI-technologists (age: *M* = 64.7). The question then becomes does this skew the results and steer the findings towards those of Henry et al. (2004)? In my view, it does not for two reasons. First as Niedzʼwienʼska, Janik, & Jarczynʼska (2013) found, older participants did perform better than younger participants did when more importance was given to what had to be remembered. Secondly, this study used a test tool that accounted for age. The RBMT-3 allowed for the conversion of raw scores to scaled scores accounting for the age of the participants.

A regression analysis was completed on (SSS) of the MRI technologists and non-MRI technologists to determine if a significant variance existed between both groups when taking into account their responses on the questionnaire. The results indicated that no significant variance existed between both groups. A regression analysis was performed on the MRI technologists taking into account a number of variables. Variables like the hours worked, years worked, type of machine worked on, and years worked on MRI machines were used in order to determine if these variables had a significant variance on the technologist's SSS. The results concluded that no significant variance exists when considering those variables.

An analysis was conducted looking into the variables solely associated with MRI technologists (i.e. hours worked per week, years worked with MRI machines, etc.). The analysis wanted to determine if these variables affected the SSS of the technologists. A regression analysis was used for this analysis. The results indicated no significant variance in the SSS of the technologists F (7, 74) = 1.280, p = .272 with an R^2 =.113. This concludes that the elevated hours worked by technologists along with other factors associated solely with their work environment had no significant difference on their results.

The health concern regarding the MRI technologist's thyroid problems was not statistically significant. The results of the questionnaire showed that MRI-technologists had a higher rate of thyroid problem versus non-MRI technologist. MRI technologists' confirmed having a 350% higher level of thyroid problems than non-MRI technologists did. Further research is necessary in this area in order to provide for clarity and solidification of the current findings. Research that will use a larger population size and cover a larger geographical area may possibly yield different statistical results.

Summary

The statistical analyses of the study data provided mixed results for hypothesis 1, but did not show a significant difference for hypothesis 2. The level of STM loss was not significant overall for MRI technologists when compared to nonMRI technologists, but was significant in the area of PM (performance of a planned action). However, there were no significant differences in the sum of scaled score of either group in various age ranges. The analysis of the health variables did not show a significant difference between both groups, but there were alarming elevated levels of thyroid problems (350% greater) within the MRI technologists population. The analysis of variables associated with only MRI technologists and their work environment did not show any significant difference.

In the following chapter, I will provide a summary of the study and present conclusions associated with the findings of the study. In Chapter 5, I will also provide the social change implications of the study and look into the findings of the study. I will review the limitations of the study. I will close Chapter 5 with recommendations for further research in this area.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

This study was conducted to look into the difference between the STM of MRI technologists and non-MRI technologists. MRI technologists are exposed to residual magnetic fields that surround the MRI machines (STM and FMF). These magnetic fields are present continuously once the MRI machines are activated. This study looked to determine if these residual magnetic fields pose a problem to the STM of MRI technologists. In order to test for any difference in memory, a number of tools were employed. These tools consisted of the RBMT-3 and the SPSS statistical analysis software.

The study looked to determine if MRI technologists had a reduced level of memory when compared to non-MRI technologists. It also looked to determine if an inference could be made between the residual magnetic fields and the results of the study. The study was conducted with the use of a quasi-experimental design. In order to test the memory of the participants, a memory test tool was used, the RBMT-3. This tool was designed by Pearson Publishing to specifically test the memory of individuals ages 5 to 96 (Wilson et al., 2012). . The tool looks to determine the person’s ability to perform everyday functions (Efklides et al., 2002).

In this chapter, I will provide a summary of the interpretations of the study. I will also further analyze both hypotheses and present a view on a determination of the hypotheses and limitations associated with the study. Finally, I will provide some recommendations for future research in the area and discuss the social change implications of the study.

Summary and Interpretation of Findings

As Whissell et al. (2009) stated, magnetic fields used on rats had an effect on their memory and caused an atrophy of the rat's hippocampus. This study could not look at the cellular structure of the hippocampus, but was able to determine its functioning capacity. The study could not directly determine if changes within the cellular structure of MRI technologists are present, but an interpretation of the data collected could help in reaching certain conclusions about the technologist' STM. The findings of the study revealed that the memory levels of MRI technologists were not statistically significantly lower than that of non-MRI technologists. However, it did indicate that a significant difference was present when it came to PM.

With the results showing a significant difference in PM of the MRI technologists group versus the control group, it could be concluded that something outside of the variables tested was the cause of this difference. Sligte et al. (2011) pointed out how magnetic fields could be used to manipulate different parts of memory. This is the case in the findings of this study. The PM was affected while the other areas did not show any significant difference. The findings of this study have also been confirmed by Squire et al. (2004) in terms of the fact that they were able to determine that isolated specific regions of the cerebral structure could be activated if targeted stimuli were used.

Hypothesis 1

Hypothesis 1 examined the difference in STMof MRI technologists versus non-MRI technologists. MRI technologists were shown to have no overall difference in their SSS. They did show a reduction in one area prospective memory (This was proven by two questions, PM9: I took something/two things with me. Do you remember what it was/they were? Do you remember what I did with them? and PM19: We have finished the test. Can you remember what things were taken from you? Can you remember where I put them?). There was a direct relationship between being an MRI technologists and a lower level of recollection of planned actions. The findings provide a foundation to reject the null hypothesis due to some significant differences being present in at least part of the technologist's memory structure. Further study in this area should be considered in order to solidify the results.

Hypothesis 2

Hypothesis 2 examined the level of STM difference between groups when variables such as age range, gender, and educational level were all considered. This was done with the use of an ANOVA. The analysis confirmed that no significant variance existed between MRI technologists' STM and the STM of non-MRI technologists. Due to these findings the null hypotheses is not rejected as the results showed that no significant difference is present. The conclusion could be reached that no significant difference in memory is present in both groups when accounting for age, gender, and educational background.

A regression analysis was performed on all of the responses given to the questions on the questionnaire; a copy of the questionnaire is included in Appendix C. The results indicated no significant difference between MRI technologists versus that of non-MRI technologists. Although not statistically significant, the questionnaire did point out a 350% difference in the rate of thyroid problems between MRI technologists versus non-MRI technologists. These findings warrant further research in this area with a larger population size.

I also conducted an analysis looking into the variables solely associated with MRI technologists (i.e., hours worked per week, years worked with MRI machines, etc.). With this analysis, I wanted to determine if these variables affected the SSS of the MRI technologists. A regression analysis was used for this analysis. The results indicated no significant variance in the sum of scaled scores of the technologists F (7, 74) = 1.280, p = .272 with an R^2 =.113. This result concludes that the elevated hours worked by technologists, along with other factors associated solely with their work environment, had no significant difference on their results.

Limitations and Future Recommendations

This study had a number of limitations. First, as part of the study, the participants were required to fill out a questionnaire. This questionnaire had numerous personal questions that a participant could have chosen to answer in a dishonest manner. It was also left to the mercy of the participants to answer the assessment questions properly. A participant could have purposely answered a questionnaire question incorrectly, which could have affected the outcome of the study. It was assumed and expected that the participants would be honest in both of these areas.

Another limitation was faced in the location where the participants were tested. The participants were not all tested in the same location, under the same conditions, and during the same time of the day. This could have influenced the outcome of this study. Another limitation was the notion that this is not a true experiment. This study used a quasi-experimental design, which was limited to MRI technologists.

Another area of concern involved holding confounding variables that were part of the study constant. It was not possible to hold all confounding variables constant. This exposed the results to be an outcome of some other factor rather than that of the magnetic fields. Additionally, this type of study is difficult to establish in an independent-dependent variable configuration, due to the human element involved. Further, this study was limited to the participants' understanding of the questions. If a participant did not understand the assessment question or the questionnaire question correctly, it could have affected the results. Finally, the study was limited to the participants within the New York/ New Jersey metropolitan area and the New Hampshire/Maine area.

Future Recommendations

This study exposed the need for further research within the area of magnetic fields and their influence on the cerebral structure. Further control studies could yield important information about the memory system and magnetic fields. A study with more control over the environment (i.e., MRI facility) could yield further knowledge in this area. A study that is able to control the research site and the amount of magnetic field exposure could provide different results. In other words, a more controlled study could yield different results.

Studies that look into the positive uses of magnetic fields should also be considered with future research studies. Finally, a more focused study that would use a larger population pool from a more diverse geographical region is highly recommended. This is specifically the case with the questions on the technologist's thyroid problems. The questionnaire revealed that MRI technologists suffered a 350% higher rate of thyroid problems versus non-MRI technologists. It is possible that a study with a larger participation pool that covered a larger geographical area could yield different results.

Conclusion

More research needs to be conducted on magnetic fields to determine their effects on everyone. What are the magnetic fields that surround the environment doing to society? Are magnetic fields safe? Could shielding at MRI facilities protect those that work around MRI machines benefit the technologists? These questions draw interest and are of importance to everyone. MRI machines are in their infancy of use and research on the magnetic fields that are part of the operation of these machines is limited. There is more research to be done in order to provide a full understanding of the functions of MRI machines and their magnetic fields.

This study focused on one component of the cerebral structure. It focused on how magnetic fields have an influence on the difference between STMof MRI technologists versus non-MRI technologists. This study provided some useful information about magnetic fields within the confines of MRI machines, which could be the initiator of further research. There is a possibility that future research could help professionals provide MRI technologists and non-technologists with a safer environment. Along these lines, further research could also help in the better understanding of the MRI machine's magnetic fields and what future challenges for this technology may be. What influences the powerful magnetic fields have on the patient's body outside of what is already known could be exposed with further research.

On the other hand, it must not be ignored that it is because of MRIs that many lives have been saved. The detailed imaging that is created by MRI machines cannot be discounted and the desire to make the machines better should be embraced. This progress should not come at the expense of the health of those that serve the medical community or the patients that entrust the manufacturers to produce safe machines. There must be a healthy balance, where both the existence of the imaging machines and the minimization of any consequences caused by their existence coincide. The hope is that someday a healthy balance could be reached providing the necessary imaging for better health, without the sacrifice of any side effects.

What is known is that changes within the bodies occur when a person is placed under the influence of the MRI machine. These changes could be as small as a sense of dizziness, stomach upsets, and disorientation. They could also be as large as getting ill with the disease of NSF. Furthermore, with this study it is now known that a constant SMF and FMF have the ability to cause memory loss (PM). The question that remains is what direction should be taken now. Would it be good for government regulation to be enforced in this field or should things continue to exist as they currently do?

This study exposed one element of a large infrastructure where many sources of magnetic fields exist. This study also demonstrated a relationship between a magnetic field and PM loss. Should this study be expanded outside the MRI facility? Considering that magnetic fields have elevated within the past 5 decades, this may not be such a bad thought. This leads into the area of social change.

Social Change

What kind of change could magnetic fields and this study produce for society? The igniting of interest in an area of thought creates change by definition. Progress is achieved through the initiated investigative interest in an area that is influential to many and this is in fact what has been the purpose of this study. The questioning of the purposes of magnetic fields, both positive and negative, and the uses of these fields is what will drive this society to creating more innovative tools for the benefit of society as a whole. The quest for answers to questions that are important to many is what social change is all about.

References

Abbott Northwestern Hospital. (2009, September). MRI shielding architectural site planning guide. (Supplemental Material). Retrieved from http://www.ets-lindgren.com/pdf/SPG-2009.pdf

Alsaleh, A. (2013). Family transitions, conduct problems, and self-esteem in elementary school in Kuwait: A quasi-experimental design. *Journal of Social Service Research, 39,* 662-674.

Anlage, S. M. (2000). High temperature superconducting radio frequency coils for NMR spectroscopy and magnetic resonance imaging. *Center for Superconductivity Research, and Material Research Science and Engineering Center*, 1-16.

Assmus, A. (1995). Early history of x rays. *Stanford University, 10*, 1-15. Retrieved from http://www.slac.stanford.edu/pubs/beamline/25/2/25-2-assmus.pdf

Baddeley, A. D. (2004). The psychology of memory. In A. D. Baddeley, M. Kopelmann, & B. A. Wilson (Eds.), *The essential handbook of memory disorders for clinicians* (pp.1-13). City, State: Wiley & Sons, Ltd. .

Balota, D. A., & Cortese, M. J., (2000). In A. E. Kazdin (Ed.), *Encyclopedia of psychology,* (Vol. 2). Washington, DC: American Psychological Association

Bartlett, J. C., & Tulving, E. (1974). Effects of temporal and semantic encoding in immediate recall upon subsequent retrieval. *Journal of Verbal Learning and Verbal Behavior, 13*(3), 297-309.

Blundell, S. (2011). Superconductivity. *New Scientist*, *212*(2837), 24-31.

Cheong, B. Y. C., & Muthupillai, R. (2010). Nephrogenic systemic fibrosis. *Texas Heart*

Institute Journal, *37* (5), 508-515.

Colbert, A. P. P., Markov, M. S., & Souder, J. S. (2008). Static magnetic field therapy: Dosimetry considerations. *The Journal of Alternative and Complementary Medicine*, *14*, 577-582.

Crowder, R. G. (1967). Short-term memory for words with a perceptual-motor interpolated activity. *Journal of Verbal Learning and Verbal Behavior*, *6*, 753-761.

Delparte, J. J., & Persinger, M. A. (2007) Brief exposures to theta-burst magnetic fields impair the consolidation of food-induced conditioned place preference. *International Journal of Neuroscience*, *117*, 295-299.

Demakis, G. J. (2004). Frontal lobe damage and test of executive processing: A meta-analysis of the category test, stroop test, and trail-making test. *Journal of Clinical and Experimental Neuropsychology*, *26*(3), 441-450.

Dixon, J. (2012). History of the cellular (cell/mobile) phone. Retrieved on September 14, 2015 from http://www.historyofthecellphone.com/http://www.ets-lindgren.com/pdf/SPG-2009.pdf

Domesick, V. B. (1969). A new look at the “Papez Circuit”. *School of Medicine*, *Harvard University*, 193-194.

Efklides, A., Yiultsi, E., Kangellidou, T., Kounti, F., Dina, F., & Tsolaki, M. (2002). Wechsler memory scale, Rivermead behavioral memory test, and everyday memory questionnaire in healthy adults and alzheimer patients. *European Journal of Psychological Assessment*, (18), 63-77.

Eichenbaum, H. (2001). The long and winding road to memory consolidation. *Nature Neuroscience, 4*(11), 1057-1058.

Eitel, C., Hindricks, G., Sommer, P. P., Wetzel, U., Bollmann, A., & Gasper, T., et al.

(2010). Safety of remote magnetic navigation in patients with pacemakers and implanted cardioverter defibrillators. University of Leipzig. doi: 10.1111/j.1540-8167.2010.01777.x.

Foster, K. J. (2011). Memory. *New Scientist, 212*(2841), 8.

Gobert, F., & Clarkson, G. (2004). Chunks in expert memory: Evidence for the magical number four…or is it two? *Memory, 12*(6), 732-747.

Gould, T. A., & Edmonds, M. (2011). How MRI works. *How Stuff Works.com*, 1-7. Retrieved from http://science.howstuffworks.com/mri7.htm.

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging 19*(1), 27-39.

Hornak, J. P. P. (1996). The basics of MRI. *HT Books*. Retrieved from www.cis.rit.edu/people/faculty/hornak.

Jerde, T. A., Lewis, S. M., Goerke, U., Gourtzelidis, P. P., Tzagarakis, C., & Lynch, J., et al., (2008). Ultra-high field parallel imaging of the superior parietal lobule during mental maze solving. *Experimental Brian Research, 187*, 551-561.

Kannala, S., Toivo, T., Alanko, T., & Jokela, K. (2009). Occupational exposure measurements of static and pulsed gradient magnetic fields in the vicinity of MRI scanners. *Physical Medical Biology, 54*(7), 2243-2257.

Lipsey, M. W., & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment. *American Psychologist Association, 48*(12), 1181-1209.

McKay, B. E., & Persinger, M. A. (2005). Complex magnetic fields enable static magnetic field cue use for rats in radial maze tasks. *International Journal of Neuroscience, 115*, 625-648.

Meli, S. C., & Persinger, M. A. (2009). Red light facilitates the sensed presence elicited by application of weak, burst-firing magnetic fields over the temporal lobes. *International Journal of Neuroscience, 119*, 68-75.

Medical-Siemens. (2013). Siemens MRI mr manual. Retrieved from http://www.medical.siemens.com/siemens/en_GLOBAL/gg_mr_FBAs/files/apps/MAGNETOM_world/MR_Manuals/MR_Basics/USA_English/Magnets_Spins_and_Resonances/Magnets_Spins_and_Resonances/Advanced/Default.htm

Miller, E. A., Watson, M. J., & Strayer, L. D. (2012). Individual difference in working memory capacity predict action monitoring and the error-related negativity. *Journal of Experimental Psychology Learning, Memory, and Cognition, 38*(3), 757-763.

Newhouse, B. (2007). H.M.'s brain and the history of memory. NPR: Retrieved from www.npr.org/templates /story.

Niedzʾwienʾska, A., Janik, B., & Jarczynʾska, A. (2013). Age-related differences in everyday prospective memory tasks: The role of planning and personal importance. *International Journal of Psychology 48*(6), 1291-1302.

Ortega, L. M., Contreras, G., & Lenz, C. O. (2009). Nephrogenic fibrosing dermopathy or nephrogenic systemic fibrosis? What we know and what we have to learn.

Nefrologia, 29(2), 109-117.

Pake, G. E. (1993). Nuclear magenetic resonance in bulk matter. *Physics Today, 10,* 46-56. doi:10.1063/1.881383

Pinel, J. P. P. J. (2006). Learning, memory, and amnesia. Bowers (6th), *Biopsychology (*pp. *261-263).* Boston, MA: Pearson Education Inc.

Raaijmakers, J. G.W. (1981). The story of the two-store model of memory: Past criticisms, current status, and future directions. *TNO Institute for Perception Soesterberg, 1-28*

Rohan, M., Parow, A., Stoll, A. L., Demopulos, C., Friedman, S., & Dager, S. (2004). Low-field magnetic stimulation in bipolar depression using an mri-based stimulator. *American Journal of Psychiatry, 161,* 93-98.

Rota, E., Nallino, M. G., Bainotti, S., & Formica, M. (2010). Nephrogenic systemic fibrosis: An unusual scleroderma-like fibrosing disorder. *Rheumatol Int*, *30,* 1389-1391.

Sharma, H. A. (2009). MRI physics-basic principles. *Acta Neuropsychiatrica, 21*, 200-201.

Sharma, H. A., & Lagopoulos, J. (2010). MRI physics-basic principles. *Acta Neuropsychiatrica*, *22,* 90-92.

Siegel, L. H. (2008). Magnetic resonance imaging design guide. *Department of Veterans Affairs Veterans Health Administration, 1-62.*

Skopec, M. (1997). A primer on medical device interactions with MRI systems (Report No. HFZ-133, 12721). Retrieved from www.fda.gov/medicaldevices/deviceregulationand guidance/guidancedocuments/ucm107721.htm.

Sligte, I. G., Wokke, M. E., Tesselaar, J. P. P., Scholte, H. S., & Lamme, V. A. F. (2011). Magnetic stimulation of the dorsolateral prefrontal cortex dissociates fragile visual short-term memory from visual working memory. *Neuropsychologia, 49,* 1578-1588.

Sowa, P. P., Rutkowska-Talipska, J., Sulkowska, U., Rutkowski, K., & Rutkowski, R. (2012). Ionizing and non-ionizing electromagnetic radiation in modern medicine. *Polish Annals of Medicine, 19,* 134-138.

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review, 99*(2), 195-231.

Squire, L. R., Stark, C. E. L., & Clark, R. E. (2004). The medial temporal lobe. *Annual Review Neuroscience, 27*, 279-306.

St-Pierre, L. S., Koren, S. A., & Persinger, M. A. (2007). Ambulatory effects of brief exposures to magnetic fields changing orthogonally in space over time. *International Journal of Neuroscience, 117,* 417-420.

St-Pierre, L. S., & Persinger, M. A. (2006). Experimental facilitation of the sensed presence is predicted by the specific pattern of the applied magnetic fields, not by suggestibility: Re-analyses of 19 experiments. *International Journal of Neuroscience, 116,* 1079-1096.

Stephen, B. (2011). Superconductivity. *New Scientist, 2837*(212), 1-11.

Sutherland, R. J., Lehmann, H., Spanswick, S. C., Sparks, F. T., & Melvin, N. R., (2006).

Growth points in research on memory and hippocampus. *Canadian Journal of Experimental Psychology, 60*(2), 166-174.

Thomas, B (2009). Creation scientist's invention continues to improve lives. *Institute for Creation Research.com* Retrieved from http://www.icr.org/article/creation-scientists-invention-continues/

Tsang, E. W., Koren, S. A., & Persinger, M. A. (2009). Specific patters of weak (1 micro tesla) transcerebral complex magnetic fields differentially affect depression, fatigue, and confusion in normal volunteers. *Electromagnetic Biology and Medicine, 28,* 365-373. doi: 10.3109/15368370903206630

U.S. Department of Health and Human Services, Food and Drug Administration (2011). Medical devices part 812 investigational device exemptions. Retrieved from http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch. cfm?CFRPart=812&s...

U.S. Food and Drug Administration. (2015). MRI. Retrieved from http://www.fda.gov/Radiation- EmittingProducts/RadiationEmittingProducts andProcedures/MedicalImagin g/ucm200086.htm#lrps

Vavken, P., Arrich, F., Schuhfried, O., & Dorotka, R. (2009). Effectiveness of pulsed electromagnetic field therapy in the management of osteoarthritis of the knee: a meta-analysis of randomized controlled trials**.** *Journal of Rehabilitation Medicine,41*(6), 406-411.

Wallace, H. (2012). Health report memory matters. *Sarasota Magazine, 34*(5), 163.

Whissell, P. P.D., Tsang, E. W., Mulligan, B. P. P., & Persinger, M. A. (2009). Prenatal exposures to lTP-patterned magnetic fields: Quantitative effects on specific limbic structures and acquisition of contextually conditioned fear. *International Journal of Neuroscience, 119,* 1-14.

Wilson, B., Cockburn, J., Baddely, A., Hiorns, R., Smith, PP., & Chalian, I., et al. (1991). The rivermead behavioural memory test. *Thames Valley Test Company Ltd,* 7-9.

Woo, J. (2002). A short history of the development of ultrasound in obstetrics and gynecology. *Humbul Humanities Hub.* Retreived from www.ob-ultrasound.net/history1.html.

Appendix A

Permission to Solicit Participants

Dear Sir/Madam

My name is Samuel Maldonado and I am a PhD student in health psychology at Walden University. I have a bachelor's degree in psychology and a master's degree in psychology. My background is in in-home psychotherapy and counseling. I am interested in pursuing my dissertation in testing the cognitive ability of magnetic resonance imaging technologist. I am currently in the process of soliciting participants that are interested in being part of the study. I am seeking your cooperation in posting a request for participants on your website, so that those that are members of your society could express their interest. I was pleased to learn from a number of individuals that your society is one of the well-established and acknowledged within your field and it is because of this that I respectfully seek your help in obtaining the needed participants for this study.

Sincerely,

Samuel Maldonado

Appendix C

For MRI technologist

RESEARCH

Medical History Questionnaire

Please be advised that your name will not appear on this form; a coding system will be used to link this appendix with the appropriate participant.

This questionnaire is for MRI technologist only:

DEMOGRAPHIC INFORMATION:

Age:_____ Height:________ Weight:_________ Gender: M F Years working with MRI machines:____ Years of Schooling completed and last Degree completed:______

MEDICAL INFORMATION: (Have you ever had any of these problems?)

Year Prolong

1. Stroke: 0------------------------O ---
---

never mild

2. Sleep Deprivation: Never O----------------------XX (number of times) in YYY(number of weeks)(Please provide the number of times(XX) within the (YYY) number of weeks that you have experienced sleep deprivation.

3. Trauma/Accidents: O----------------------O
yes no

*If yes please explain:*____
____
______
____
______

4. Stress: O------------------O-------------------------O
Significant minimal none

*If significant please explain:*____

____
____
____
____

5. Depression: O------------------O
no yes
How many episodes? O-------------O--------------------------O
1-3 4-6 7-10

6. Did you ever suffer from anxiety disorder?
O---------------------O-
Yes no
*If so, when and for how long?*____
____
____

7. Insomnia: O--------------------- O
Yes no
*If yes please explain:*____
____
____
____
____

8. Thyroid Problems: O---------------O
Yes no

9. Sleep Apnea: O----------------O
Yes no

10. Nutritional Deficiency: O---------O
Yes no

11. Traumatic Brian Injury: O---------O
Yes no
*If yes, please explain:*____

12. Ever have a sexually transmitted disease?

O-----------O
Yes no

13. Have you ever gotten shock therapy for Depression?

O O
Yes No

Employment Questions: For MRI technologist only.

1. *How long have you been employed within the imaging profession, in years ?*
   0 1-5 O 6-10 O 11-15 O 16-20 O 21-greater
2. *What type of machine does your facility use? O MRI O x-ray O CT scan*
3. *Does your facility use a permanent magnet MRI machine? O Yes O No*
4. *Do you work on a machine other than an MRI machine? O Yes O No*
5. *How many hours do you work per week?______*

PERSONAL HABITS

1. Alcohol Use? How many drinks per week?__________ _ # of Years?______________

2. Tobacco Use? How Much?________________ # of Years?_____________________

3. Exercise regularly? O Yes O No How Many Hours per week?_______________

4. Activity?____

PRESCRIPTION MEDICINE: If you are currently, taking medications please indicate below. Some medications may have an effect on an individual's cognitive abilities.

1. Anti-Depressants	*O yes*	*O no*
2. Anti-Anxiety Medication	*O yes*	*O no*
3. Muscle Relaxants	*O yes*	*O no*
4. Tranquilizer	*O yes*	*O no*
5. Anti-Histamine or Cold Medication	*O yes*	*O no [cold meds?]*
6. Sleeping Pills	*O yes*	*O no*
7. Supplements	*O yes*	*O no*

If yes, please describe:__________________
____
____

8. Pain Medication	*O yes*	*O no*

If yes, please describe:

Appendix C

For non-MRI technologist

RESEARCH

Medical History Questionnaire

Please be advised that your name will not appear on this form; a coding system will be used to link this appendix with the appropriate participant.

This questionnaire is for non-MRI technologist only:

DEMOGRAPHIC INFORMATION:

Age:_____ Height:_________ Weight:__________ Gender: M F   Years of Schooling completed and last Degree completed:_______

MEDICAL INFORMATION: (Have you ever had any of these problems?)

Year Prolong

1. Stroke: 0------------------------O ------

never mild

2. Sleep Deprivation: Never O----------------------XX (number of times) in YYY(number of weeks)(Please provide the number of times(XX) within the (YYY) number of weeks that you have experienced sleep deprivation.

3. Trauma/Accidents: O----------------------O

yes no

*If yes please explain:*____

____

____

4. Stress: O-----------------O-------------------------O

Significant minimal none

*If significant please explain:*____

____

____

5. Depression: O------------------O
no yes
How many episodes? O-------------O--------------------------O
1-3 4-6 7-10

6. Did you ever suffer from anxiety disorder?
O---------------------O-
Yes no
*If so, when and for how long?*____
____

7. Insomnia: O--------------------- O
Yes no
*If yes please explain:*____
____
____

8. Thyroid Problems: O---------------O
Yes no

9. Sleep Apnea: O----------------O
Yes no

10. Nutritional Deficiency: O---------O
Yes no

11. Traumatic Brian Injury: O---------O
Yes no
*If yes, please explain:*____

---

12. Ever have a sexually transmitted disease?
O-----------O
Yes no
13. Have you ever gotten shock therapy for Depression?

O Yes O No

PERSONAL HABITS

1. Alcohol Use? How many drinks per week? _ # of Years?______________

2. Tobacco Use? How Much?________________ # of Years?____________________

3. Exercise regularly? O Yes O No How Many Hours per week?_______________

4. Activity?____

PRESCRIPTION MEDICINE: If you are currently taking medications please indicate below. Some medications may have an effect on an individual's cognitive abilities.

1. Anti-Depressants O yes O no

2. Anti-Anxiety Medication O yes O no

3. Muscle Relaxants O yes O no

4. Tranquilizer O yes O no

5. Anti-Histamine or Cold Medication O yes O no[cold meds?]

6. Sleeping Pills O yes O no

7. Supplements O yes O no

If yes, pleasedescribe:____________

____

____

8. Pain Medication O yes O no

If yes, please describe:

____

____

_____

Appendix D

Email Correspondence between Fort Lee Public Library and Samuel Maldonado Regarding the use of the room for the Administering of the Cognitive Test

Dear Sir/Madam

My name is Samuel Maldonado and I am a student at Walden University. I am required to complete a dissertation as part of my studies and in order to obtain my Ph. D. At this current time, I am in progress of selecting a group of participants that will be a part of a research study testing their short-term memory abilities. It is because of this that I am writing this letter. I am in need of a room in order to administer the memory test. As a Fort Lee resident, I wanted to inquire with my local library to determine if they could provide the previously mentioned room. I expect to use the room on a number of occasions, which should not last longer than one hour during every use. I appreciate your help with this inquiry.

Respectfully,

Samuel Maldonado

Appendix E

An ANOVA that looks at the difference between technologists and non-technologists:

0 = non-MRI technologists
1 = MRI-technologists

```
ONEWAY SumofScaledScores BY Tech_YN
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS
```

Oneway

Descriptives

SumofScaledScores

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	41	128.29	12.422	1.940	124.37	132.21	98	151
1	41	122.49	17.235	2.692	117.05	127.93	91	151
Total	82	125.39	15.213	1.680	122.05	128.73	91	151

ANOVA

SumofScaledScores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	690.780	1	690.780	3.061	.084
Within Groups	18054.732	80	225.684		
Total	18745.512	81			

```
ONEWAY ScaledScoreQ5 ScaledScoreQ6 ScaledScoreQ8 ScaledScoreQ9 ScaledScoreQ10
ScaledScoreQ11 ScaledScoreQ12 ScaledScoreQ13 ScaledScoreQ14 ScaledScoreQ15 ScaledScoreQ16
ScaledScoreQ17 ScaledScoreQ18 ScaledScoreQ19 BY Tech_YN
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.
```

This analysis looks at each subsection question.

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
ScaledScoreQ5	0	41	7.80	2.731	.427	6.94	8.67	2	13
	1	41	8.61	2.344	.366	7.87	9.35	4	13
	Total	82	8.21	2.562	.283	7.64	8.77	2	13
ScaledScoreQ6	0	41	9.90	2.022	.316	9.26	10.54	4	11
	1	41	9.29	2.358	.368	8.55	10.04	4	11
	Total	82	9.60	2.205	.243	9.11	10.08	4	11
ScaledScoreQ8	0	41	11.00	.949	.148	10.70	11.30	7	13
	1	41	13.73	17.381	2.714	8.25	19.22	6	122
	Total	82	12.37	12.309	1.359	9.66	15.07	6	122
ScaledScoreQ9	0	41	10.37	1.757	.274	9.81	10.92	4	11
	1	41	8.76	2.663	.416	7.92	9.60	2	11
	Total	82	9.56	2.384	.263	9.04	10.08	2	11
ScaledScoreQ10	0	41	9.68	2.876	.449	8.78	10.59	3	15
	1	41	10.71	2.620	.409	9.88	11.53	4	16
	Total	82	10.20	2.782	.307	9.58	10.81	3	16
ScaledScoreQ11	0	41	4.46	1.748	.273	3.91	5.02	1	7
	1	41	5.20	1.806	.282	4.63	5.77	1	9
	Total	82	4.83	1.804	.199	4.43	5.23	1	9
ScaledScoreQ12	0	41	7.32	2.770	.433	6.44	8.19	1	13
	1	41	6.51	2.740	.428	5.65	7.38	1	11
	Total	82	6.91	2.768	.306	6.31	7.52	1	13
ScaledScoreQ13	0	41	10.07	2.443	.382	9.30	10.84	3	13
	1	41	9.44	3.529	.551	8.33	10.55	3	13
	Total	82	9.76	3.033	.335	9.09	10.42	3	13
ScaledScoreQ14	0	41	8.66	2.243	.350	7.95	9.37	3	13
	1	41	8.88	2.542	.397	8.08	9.68	5	15
	Total	82	8.77	2.385	.263	8.24	9.29	3	15
ScaledScoreQ15	0	41	10.93	1.058	.165	10.59	11.26	7	13
	1	41	10.83	1.801	.281	10.26	11.40	5	12
	Total	82	10.88	1.469	.162	10.56	11.20	5	13

	0	41	9.83	2.519	.393	9.03	10.62	1	11
ScaledScoreQ16	1	41	8.80	2.722	.425	7.95	9.66	2	11
	Total	82	9.32	2.657	.293	8.73	9.90	1	11
	0	41	8.17	2.692	.420	7.32	9.02	1	13
ScaledScoreQ17	1	41	7.34	3.329	.520	6.29	8.39	1	12
	Total	82	7.76	3.037	.335	7.09	8.42	1	13
	0	41	9.27	2.684	.419	8.42	10.12	3	12
ScaledScoreQ18	1	41	9.00	2.793	.436	8.12	9.88	2	12
	Total	82	9.13	2.725	.301	8.54	9.73	2	12
	0	41	10.83	2.155	.337	10.15	11.51	1	13
ScaledScoreQ19	1	41	8.07	3.488	.545	6.97	9.17	1	13
	Total	82	9.45	3.198	.353	8.75	10.15	1	13

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	13.280	1	13.280	2.050	.156
ScaledScoreQ5	Within Groups	518.195	80	6.477		
	Total	531.476	81			
	Between Groups	7.622	1	7.622	1.579	.213
ScaledScoreQ6	Within Groups	386.098	80	4.826		
	Total	393.720	81			
	Between Groups	152.976	1	152.976	1.010	.318
ScaledScoreQ8	Within Groups	12120.049	80	151.501		
	Total	12273.024	81			
	Between Groups	53.122	1	53.122	10.440	.002
ScaledScoreQ9	Within Groups	407.073	80	5.088		
	Total	460.195	81			
	Between Groups	21.512	1	21.512	2.843	.096
ScaledScoreQ10	Within Groups	605.366	80	7.567		
	Total	626.878	81			
	Between Groups	10.976	1	10.976	3.476	.066
ScaledScoreQ11	Within Groups	252.634	80	3.158		
	Total	263.610	81			
ScaledScoreQ12	Between Groups	13.280	1	13.280	1.750	.190

	Within Groups	607.122	80	7.589		
	Total	620.402	81			
ScaledScoreQ13	Between Groups	8.244	1	8.244	.895	.347
	Within Groups	736.878	80	9.211		
	Total	745.122	81			
ScaledScoreQ14	Between Groups	.988	1	.988	.172	.680
	Within Groups	459.610	80	5.745		
	Total	460.598	81			
ScaledScoreQ15	Between Groups	.195	1	.195	.089	.766
	Within Groups	174.585	80	2.182		
	Total	174.780	81			
ScaledScoreQ16	Between Groups	21.512	1	21.512	3.128	.081
	Within Groups	550.244	80	6.878		
	Total	571.756	81			
ScaledScoreQ17	Between Groups	14.098	1	14.098	1.539	.218
	Within Groups	733.024	80	9.163		
	Total	747.122	81			
ScaledScoreQ18	Between Groups	1.476	1	1.476	.197	.659
	Within Groups	600.049	80	7.501		
	Total	601.524	81			
ScaledScoreQ19	Between Groups	155.720	1	155.720	18.522	.000
	Within Groups	672.585	80	8.407		
	Total	828.305	81			

Appendix F

A Regression with demographics:

```
GET DATA /TYPE=XLSX
  /FILE='C:\Users\SB258017\Documents\My Documents\RESEARCH\Copy of sam excel with scaled scores.xlsx'
  /SHEET=name 'Sheet1'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT SumofScaledScores
  /METHOD=ENTER TechYN Height Weight Gender LastDegree.
```

THE DV IS SUMOFSCALEDSCORES. THE PREDICTORS ARE TECH STATUS AND SOME DEMOGRAPHICS.

Regression

Notes

Output Created		06-JUL-2015 14:33:59
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	999
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT SumofScaledScores /METHOD=ENTER TechYN Height Weight Gender LastDegree.
Resources	Processor Time	00:00:00.05
	Elapsed Time	00:00:00.10

	Memory Required	8096 bytes
	Additional Memory Required for Residual Plots	0 bytes

[DataSet1]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Last Degree, Gender, Tech Y/N, Weight, Height[b]	.	Enter

a. Dependent Variable: Sum of Scaled Scores

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.458[a]	.210	.158	13.9612

a. Predictors: (Constant), Last Degree, Gender, Tech Y/N, Weight, Height

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3932.063	5	786.413	4.035	.003[b]
	Residual	14813.449	76	194.914		
	Total	18745.512	81			

a. Dependent Variable: Sum of Scaled Scores

b. Predictors: (Constant), Last Degree, Gender, Tech Y/N, Weight, Height

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-32.288	47.161		-.685	.496
	Tech Y/N	-2.339	3.418	-.077	-.684	.496

	Height	2.208	.680	.532	3.247	.002
	Weight	-.046	.045	-.129	-1.014	.314
	Gender	16.491	4.423	.535	3.728	.000
	Last Degree	-2.849	1.925	-.166	-1.480	.143

a. Dependent Variable: Sum of Scaled Scores

<u>This Model adds in the Health Questions. The overall model is not significant. None of the individual health questions add significant variance to the model.</u>

```
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT SumofScaledScores
  /METHOD=ENTER TechYN Height Weight Gender LastDegree Alcoholuse DrinksperWeek YearsdrinkingAlcohol TobaccoUse
HowmuchTobaccoUse#ofYears ExerciseRegularly Hourperweekexercise Activity AntiDepressants AntiAnxietyMedicatio
MuscleRelaxants Tranquilizer AntiHistamine SleepingPills Supplements PainMedication Stroke SleepDeprivation TraumaAccidents
Stress Depression EpisodesofDepression AnxietyDisorder PeriodsofAnxietyDisorder Insomnia PeriodsofInsomnia ThyroidProblems
SleepApnea NutritionalDeficiency
TraumaticBrainInjury SexuallyTransmittedDisease ShockTherapy.
```

Regression

Notes

Output Created		06-JUL-2015 14:35:21
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	999
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.

Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT SumofScaledScores /METHOD=ENTER TechYN Height Weight Gender LastDegree Alcoholuse DrinksperWeek YearsdrinkingAlcohol TobaccoUse HowmuchTobaccoUse#ofYears ExerciseRegularly Hourperweekexercise Activity AntiDepressants AntiAnxietyMedicatio MuscleRelaxants Tranquilizer AntiHistamine SleepingPills Supplements PainMedication Stroke SleepDeprivation TraumaAccidents Stress Depression EpisodesofDepression AnxietyDisorder PeriodsofAnxietyDisorder Insomnia PeriodsofInsomnia ThyroidProblems SleepApnea NutritionalDeficiency TraumaticBrainInjury SexuallyTransmittedDisease ShockTherapy.
Resources	Processor Time	00:00:00.06
	Elapsed Time	00:00:00.06
	Memory Required	62624 bytes
	Additional Memory Required for Residual Plots	0 bytes

Warnings

For models with dependent variable Sum of Scaled Scores, the following variables are constants or have missing correlations: Stroke, Sexually Transmitted Disease, Shock Therapy. They will be deleted from the analysis.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.697[a]	.486	.115	14.3140

a. Predictors: (Constant), Traumatic Brain Injury, Years drinking Alcohol, Weight, Thyroid Problems, Anti-Histamine, Anti-Anxiety Medicatio, Muscle Relaxants, Periods of Insomnia, Nutritional Deficiency, Tobacco Use, Tech Y/N, Activity, Trauma/Accidents, Depression, Sleep Apnea, Pain Medication, Drinks per Week, Stress, Gender, Anti-Depressants, Supplements, Last Degree, How much Tobacco Use # of Years, Sleep Deprivation, Hour per week exercise, Anxiety Disorder, Sleeping Pills, Alcohol use, Height, Exercise Regularly, Insomnia, Periods of Anxiety Disorder, Tranquilizer, Episodes of Depression

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9115.641	34	268.107	1.309	.195[b]
	Residual	9629.871	47	204.891		
	Total	18745.512	81			

a. Dependent Variable: Sum of Scaled Scores

b. Predictors: (Constant), Traumatic Brain Injury, Years drinking Alcohol, Weight, Thyroid Problems, Anti-Histamine, Anti-Anxiety Medicatio, Muscle Relaxants, Periods of Insomnia, Nutritional Deficiency, Tobacco Use, Tech Y/N, Activity, Trauma/Accidents, Depression, Sleep Apnea, Pain Medication, Drinks per Week, Stress, Gender, Anti-Depressants, Supplements, Last Degree, How much Tobacco Use # of Years, Sleep Deprivation, Hour per week exercise, Anxiety Disorder, Sleeping Pills, Alcohol use, Height, Exercise Regularly, Insomnia, Periods of Anxiety Disorder, Tranquilizer, Episodes of Depression

Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	T	Sig.
1 (Constant)	-84.014	112.935		-.744	.461
Tech Y/N	-4.101	4.319	-.136	-.949	.347
Height	1.041	.903	.251	1.153	.255
Weight	-.004	.062	-.012	-.068	.946
Gender	11.061	6.053	.359	1.827	.074
Last Degree	-2.376	2.612	-.138	-.910	.368
Alcohol use	-5.688	6.176	-.186	-.921	.362
Drinks per Week	.730	1.035	.127	.705	.484
Years drinking Alcohol	.017	.187	.016	.090	.929
Tobacco Use	3.333	6.806	.075	.490	.627
How much Tobacco Use # of Years	.233	.386	.099	.604	.549
Exercise Regularly	3.102	7.459	.100	.416	.679
Hour per week exercise	-.387	.778	-.108	-.498	.621
Activity	-7.702	6.662	-.215	-1.156	.253
Anti-Depressants	15.192	11.902	.216	1.276	.208
Anti-Anxiety Medicatio	-4.531	24.450	-.046	-.185	.854

Muscle Relaxants	1.622	10.489	.020	.155	.878
Tranquilizer	-32.595	34.324	-.333	-.950	.347
Anti-Histamine	6.762	5.876	.163	1.151	.256
Sleeping Pills	14.480	15.639	.206	.926	.359
Supplements	-1.917	4.504	-.063	-.426	.672
Pain Medication	10.313	7.134	.223	1.446	.155
Sleep Deprivation	8.254	6.571	.205	1.256	.215
Trauma/Accidents	-5.226	4.803	-.151	-1.088	.282
Stress	3.074	3.959	.115	.776	.441
Depression	-11.300	12.281	-.326	-.920	.362
Episodes of Depression	-.320	2.873	-.042	-.111	.912
Anxiety Disorder	17.226	11.052	.472	1.559	.126
Periods of Anxiety Disorder	2.176	1.809	.428	1.203	.235
Insomnia	-1.667	11.781	-.038	-.142	.888
Periods of Insomnia	-1.148	1.675	-.171	-.685	.497
Thyroid Problems	-3.683	6.127	-.076	-.601	.551
Sleep Apnea	3.444	8.699	.055	.396	.694
Nutritional Deficiency	6.143	11.557	.088	.532	.598
Traumatic Brain Injury	46.789	41.099	.340	1.138	.261

a. Dependent Variable: Sum of Scaled Scores

In this regression only the techs are included.

The experience and machine variables are included.

Regression

Notes

Output Created		06-JUL-2015 14:37:10
Comments		
Input	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>

	N of Rows in Working Data File	999
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT SumofScaledScores /METHOD=ENTER TechYN YearsworkingwithMRIMachines YearsasTechnologist TypeofMachineused PermanentMagnet WorkonotherMachine Hoursworkedperweek.
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.01
	Memory Required	9584 bytes
	Additional Memory Required for Residual Plots	0 bytes

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Hours worked per week, Type of Machine used, Years working with MRI Machines, Work on other Machine, Permanent Magnet, Tech Y/N, Years as Technologist[b]	.	Enter

a. Dependent Variable: Sum of Scaled Scores

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.329[a]	.108	.024	15.0320

a. Predictors: (Constant), Hours worked per week, Type of Machine used, Years working with MRI Machines, Work on other Machine, Permanent Magnet, Tech Y/N, Years as Technologist

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2024.472	7	289.210	1.280	.272[b]
	Residual	16721.040	74	225.960		
	Total	18745.512	81			

a. Dependent Variable: Sum of Scaled Scores

b. Predictors: (Constant), Hours worked per week, Type of Machine used, Years working with MRI Machines, Work on other Machine, Permanent Magnet, Tech Y/N, Years as Technologist

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	128.244	2.336		54.899	.000
Tech Y/N	-5.152	10.570	-.170	-.487	.627
Years working with MRI Machines	-.429	.553	-.289	-.776	.440
Years as Technologist	3.618	2.903	.515	1.246	.217
Type of Machine used	.128	1.824	.014	.070	.944
Permanent Magnet	-1.999	4.899	-.112	-.408	.684
Work on other Machine	6.992	5.810	.396	1.203	.233
Hours worked per week	-.385	.224	-.547	-1.722	.089

a. Dependent Variable: Sum of Scaled Scores

```
USE ALL.
COMPUTE filter_$=(TechYN = 1).
VARIABLE LABELS filter_$ 'TechYN = 1 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT SumofScaledScores
```

/METHOD=ENTER YearsworkingwithMRIMachines YearsasTechnologist TypeofMachineused PermanentMagnet WorkonotherMachine Hoursworkedperweek.

Regression

Notes

Output Created		06-JUL-2015 14:38:33
Comments		
Input	Active Dataset	DataSet1
	Filter	TechYN = 1 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	40
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION /MISSING LISTWISE /STATISTICS COEFF OUTS R ANOVA /CRITERIA=PIN(.05) POUT(.10) /NOORIGIN /DEPENDENT SumofScaledScores /METHOD=ENTER YearsworkingwithMRIMachines YearsasTechnologist TypeofMachineused PermanentMagnet WorkonotherMachine Hoursworkedperweek.
Resources	Processor Time	00:00:00.03
	Elapsed Time	00:00:00.02
	Memory Required	8832 bytes
	Additional Memory Required for Residual Plots	0 bytes

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Hours worked per week, Type of Machine used, Years as Technologist, Permanent Magnet, Work on other Machine, Years working with MRI Machines[b]	.	Enter

a. Dependent Variable: Sum of Scaled Scores

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.336[a]	.113	-.049	17.8707

a. Predictors: (Constant), Hours worked per week, Type of Machine used, Years as Technologist, Permanent Magnet, Work on other Machine, Years working with MRI Machines

The overall model is not significant. None of the experience and machine variables add unique significant variance to the model.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1337.003	6	222.834	.698	.653[b]
	Residual	10538.897	33	319.361		
	Total	11875.900	39			

a. Dependent Variable: Sum of Scaled Scores

b. Predictors: (Constant), Hours worked per week, Type of Machine used, Years as Technologist, Permanent Magnet, Work on other Machine, Years working with MRI Machines

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	120.810	18.161		6.652	.000
Years working with MRI Machines	-.450	.668	-.229	-.673	.505
Years as Technologist	3.816	3.634	.344	1.050	.301
Type of Machine used	.298	2.381	.024	.125	.901
Permanent Magnet	-1.690	6.089	-.049	-.277	.783
Work on other Machine	7.260	7.076	.208	1.026	.312
Hours worked per week	-.371	.278	-.250	-1.333	.192

a. Dependent Variable: Sum of Scaled Scores

Appendix G

Summary of Scores Table

Verbal Memory:	Question #5
	Question #14
	Question #18
Visual Memory	Question #6
	Question #10
Spatial Memory	Question #8
	Question #15
Prospective Memory	Question #9
	Question #13
	Question #16
	Question #19
Orien/Date	Question #11
New Learning	Question #12
	Question #17

Appendix H

Feedback Summary:

This feedback summary is given to all that have participated in the study being conducted by Mr. Sam Maldonado. The feedback from this summary will assist me in understanding your experience when taking the assessment and provide me with useful information to make appropriate changes. The summary will consist of five questions that you are asked to rate with the use of a scale from 1 to 5. The 5 indicates the highest level of satisfaction and the 1 indicates the lowest level of satisfaction.

1. How was your experience in this research study? Please circle one that fits your view 1 2 3 4 5
2. Were you greeted in a positive manner when arriving at location? Please circle one that fits your view 1 2 3 4 5
3. Was your experience with the student (Sam Maldonado) positive? Please circle one that fits your view 1 2 3 4 5
4. What was your overall opinion of the assessment? Please circle one that fits your view 1 2 3 4 5
5. Do you have any additional comments? Please circle one that fits your view

   Thank you for your cooperation in completing this feedback summary.