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Meditation and Cognitive Function Research Study

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MEDITATION AND COGNITIVE FUNCTION RESEARCH STUDY

by

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ABSTRACT

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Although research has shown that long-term guided meditation and mindfulness practices improve attention, memory, and processing speed, the research on the effects of short-term self-guided meditation on improving cognitive processing and memory is limited. This study examined whether a brief self-guided meditation practice improved cognitive processing speed and memory capacity. The participants engaged in a five-day program which consisted of taking an online mental speed test and memory recall test, then meditated for 15 minutes a day, for five days. After completing the five-day meditation program, the participants took the two cognitive processing tests again. The results on the test scores showed an average increase in three points in the mental test and two points in the memory test scores. A paired-sample equal variance *t*-test determined there was no significant statistical difference made by the five-day meditation experiment. These findings in this study build on the knowledge and understanding of the impact of short-term meditation.

Keywords: Meditation, Cognitive processing, Working memory capacity, Short-term meditation practice.

This thesis is dedicated to Harry and Jean Landry. My loving parents who patiently encouraged the pursuit of education throughout my life.

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TABLE OF CONTENTS

List of Tables

CHAPTER 1

INTRODUCTION

Meditation, defined as a contemplative, self-regulatory practice that induces a state of relaxation or altered state of awareness, has many benefits attributed to its practice (Alexander et al., 2003; Bertone, 2020; Zeidan et al., 2010). There is a growing body of scientific research being conducted concerning these benefits in overlapping areas such as psychological health, well-being, and cognitive function (i.e., the mental processes of attention control, working memory, processing speed, long-term memory, perception, reading comprehension and problem-solving.)

Studies examining the effects of meditation on psychological health indicate decreases in anxiety levels, addictive behaviours, depression, stress-cortisol levels, and blood pressure (Baer et al., 2003; Chung, et al., 2012; Germer et al., 2005; Hayes et al., 2004; Manocha et al., 2011; Schreiner, & Malcolm, 2008; Singh et al., 2007). Research studies have also demonstrated a relationship between meditation and increased performance in cognitive function such as awareness, attention, memory, and mental processing speed (Badart et al., 2018; Chambers et al., 2008; Ebaid et al., 2017; Heeren et al., 2009; Jha et al., 2007; Mrazek et al., 2013; Rothschild, et al., 2017). These benefits tend to impact each other; for example, improvements in psychological health have been shown to improve cognitive function (Bunce et al., 2008; Llewellyn et al., 2008). Similarly, improvements in one area of cognitive function have an effect on other areas, such as gray-matter volume, sleep quality, blood flow in the brain, and psychomotor speed (Cranson et al., 1991; Hölzel et al., 2011; Jedrczak et al., 1986; Pagnoni & Cekic, 2007; Sun et al., 2013).

This study focused on the effects of meditation on two areas of cognitive function: processing speed and working memory. Processing speed is defined as the speed at which one processes information (Lichtenberger & Kaufman, 2012). Working memory is defined as a small amount of information that can be held in the mind for cognitive tasks (Nelson, 2014). The term is often used in the field of psychology to describe and measure intelligence, information processing, learning, and problem-solving (Jha et al., 2010). It is differentiated from long-term memory which is the vast amount of information accumulated during one's life.

The body of research reviewed generally examined the benefits of formal meditation programs lasting eight weeks or longer, or where the participants had years of meditation practice prior to the study (Hall, 1999; Helber et al. 2012; Jha et al., 2010; Katherine et al. 2010; Monk-Turner, 2003). For example, one popular mindfulness based program used by psychologists and some medical treatment facilities called the Mindfulness-based stress reduction program (MBSR) lasts eight weeks, followed by a one day six-hour session (Carmody & Baer 2009). Several studies have been conducted on the effects of a meditation program called Transcendental Meditation (TM). The participants practice for periods ranging from six months to 20 months (Alexander et al., 2003). These programs require extensive time and financial commitment, and as a result, lack accessibility to a wide population.

It is important to investigate whether shorter programs of meditation, practiced for a brief period each day, can improve cognitive function. A short-term self-guided program is available to a wider population than formal, long-term, supervised meditation program. To some the former would be more affordable. Demonstrated meditation benefits could extend to job performance, student test taking, and overall well-being. This research study examined the

meditation benefits on cognitive function of an informal, short, self-guided meditation session lasting five days.

Problem Statement

Long-term meditation programs lasting eight weeks or longer have established positive physical and mental benefits of practicing meditation. (Baer et al., 2003; Chung, et al., 2012; Germer et al., 2005; Hayes et al., 2004; Jha et al., 2010; Manocha et al., 2011; Schreiner, & Malcolm, 2008; Singh et al., 2007). These are often long-term formal programs guided by a qualified coach or experienced meditator.

The purpose of this study was to determine relationship between a self-guided short-term meditation program and its impact on memory capacity and cognitive processing speed. Does a short-term self-guided meditation program show any improvements in memory capacity or cognitive processing speed?

Research Questions

RQ1: Does short-term self-guided mediation practice impact cognitive processing speed?

RQ2: Does short-term self-guided meditation practice impact working memory?

Background and Significance

The earliest records of meditation practice (dating back to around 1500 BC) were found in India within the Vedic schools of Hindu traditions for the spiritual path to enlightenment (Wynne, 2007). The Chinese Taoists and Indian Buddhist practices began to develop their own systems in the sixth and fourth centuries BC (Wynne, 2007). Meditation practices tend to fall into two broad categories; one is an attentional concentrative focus method, in which one focuses on a thought or activity. The other is a “day-dreaming” type process that

involves the practitioner passively observing and allowing any thoughts and feelings to arise without any judgements or analysis. This usually involves staying in the present moment as a passive observer. The latter is often referred to as mindfulness. The distinction between the two is minor because they both involve some degree of attention control. Several formal systems have evolved from each category.

Popular concentrative focus methods include mantra meditation, Transcendental Meditation, Yoga breath-focusing meditations, and Progressive Muscle Relaxation (PMR) (Alexander et al., 2003; Bertone, 2020). Mindfulness methods include the Mindfulness-based stress reduction program, Integrative body–mind training (IBMT), movement meditation, and the practice of Hatha Yoga (Tang et al., 2007; Zeidan et al., 2010).

Research on the benefits and effects of meditation are growing. Research on long-term meditation has shown that it decreases anxiety and depression and increases feelings of well-being (Baer 2003; Schreiner & Malcolm 2008). When it comes to cognitive function, research studies have shown improved performance with regards to attention, awareness, memory, and mental processing (Jha et al., 2007; Jha et al., 2010). Many of these meditation courses involve programs that last anywhere from eight to 24 weeks. Some meditation programs involve concentrated retreats that involve full-time commitments lasting two to seven days. For many, committing to lengthy periods of time, or committing to the financial requirements needed, is not feasible. This begs the question, is it possible to obtain these benefits with only one week of meditation practice? If one can improve memory, attention control, mental processing speed, and increased feelings of well-being, then this would apply to many areas of a person's life. A person's job performance, students' test taking skills and scores, and general mental and physical well-being could improve with briefer meditation sessions. There is a business philosophy for

improvement in Japan called *Kaizen* in which involves small continuous improvements in workplace practices and personal efficiency (Masaaki, 1986). Small improvements over time make big improvements overall, but what about small improvements over shorter time periods? It may mean the difference between achieving a higher grade, time shaved off a time-consuming work project, or the difference in a competitive promotion. Olympic athletes win events and races by fractions of an inch or hundredths of a second. Small increments can mean a lot. Small segments of meditation may mean important improvements in one's life.

Limitations

The limitations of this study are as follows:

1. This study was limited to a sample of college students currently attending a single southeastern four-year university.
2. This study was limited by the quality and duration of the participants' meditation sessions, since it was self-guided and the researcher was not able to monitor their sessions.
3. The test scores of the participants were self-reported.
4. The online testing score was capped at 100. If a participant scored 100 on the pre-test, there was no way to accurately measure growth for those that scored 100 on their post-test.

Assumptions

In this study there were several factors and conditions that were assumed to be true and factual.

The assumptions were as follows:

1. A change in test scores following meditation was a result in meditation.
2. The participants answered the forms and survey questions honestly and accurately.
3. The participants completed the full five-day program.

4. The participants have responded truthfully and to the best of their ability.

Definition of Terms

Cognitive processing speed, is defined as the speed at which one processes information for cognitive tasks or cognitive functions (Ebaid et al., 2017)

Electroencephalography (EEG) is a test that measures and records the electrical activity of the brain by placing electrodes on the scalp. These signals are then translated into wave frequencies on an EEG recording. These waves can then detect brain synchronization or any disorders that may be occurring in certain regions of the brain. (Izzetoglu et al., 2020)

Functional near infrared spectroscopy (fNIRS) has been used successfully to monitor cognitive states and brain activity. Using head-worn electrode sensors, the technique employs near-infrared light and advanced signal processing to allow real-time, in-task monitoring. The system not only determines changes in cognitive states by tracking blood hemoglobin levels in the brain, but also filters non-relevant artifacts, such as the probes' own motion, rendering the collected data even more accurate. The brains of people can be scanned to see which part of their brains are being activated, and which portions of the brain receive an increase in blood flow. (Izzetoglu et al., 2020)

d2-concentration and endurance test is a timed test that assesses selective attention. This test is used in many areas of psychology, which allows for measurements of attention, concentration, processing speed, and rule compliance (Moore, & Malinowski, 2009).

Integrative body–mind training (IBMT) - created by Yi-Yuan Tang of Dalian University of Technology in the 1990’s. The program integrated traditional Chinese medicine practices with progressive body relaxation, mental imagery, and guided mindfulness training. Tang has used this form of mindfulness for some of his research studies. (Tang et al., 2007)

Meditation is the practice of directing the attention of the mind, in order to relax the body and calm the mind, which can lead to altered states of consciousness. These mental states positively improve psychological balance and overall well-being. The practice tends to divide into two types of methods: a narrow concentrative focus method and a broad, non-focusing, "day dreaming" type method. The concentrative method can be used on any type of focusing theme like the breath, exercise, visual images, affirmations, prayers, sounds, etc. The non-focusing method requires one to simply be passively observant, yet let go of any thought, feeling, analysis or judgement that comes into consciousness. (Alexander et al., 2003; Bertone, 2020; Zeidan et al., 2010)

Mindfulness is moment-by-moment focus of awareness of current experiences that are observed without analysis or judgement. This process can be done in sitting stillness or during low cognitive load activities like eating, walking, or practicing yoga. (Baer 2003)

Mindfulness-based stress reduction program (MBSR) is an eight-week program in which practitioners receive training in mindfulness meditation techniques linked with certain physical stretches and yoga exercises for three hours a day for eight weeks, followed by a one-day retreat. (Schreiner & Malcolm 2008).

Progressive Muscle Relaxation (PMR) This program focuses on tensing major muscle groups for a short period of time, then relaxing them. Over a period of time, the practitioner will become aware of the body and the condition it is in. Stress induces tension in the body. By practicing PMR one learns to become aware of unnecessary muscle tension and return to a relaxed state. (Mallya & Fiocco 2016)

Sahaja Yoga (SY) meditation is a Hindu-based self-realization technique that attempts to obtain a state of mental silence and enlightenment through focusing on the present moment. (Dodich et al. 2019)

Stroop color word task (SCWT) is a neuropsychological test that measures the ability to inhibit cognitive interference. An example would be the ability to inhibit habits in order to achieve a goal that has cognitive interference. An example would be the actual Stroop Color Word Task test. The test goal is to read out loud and name a physical color when it is used to spell the name of a different color. The test can measure multiple cognitive functions such at attention, processing speed and cognitive flexibility. (Scarpina, & Tagini, 2017; Stroop, 1935).

Transcendental Meditation is a program in which the participant focuses on a mantra for 20 minutes a day, twice a day, for one week. Formal programs consist of coaches that guide the participant through the process efficiently and effectively. (Goodman et al., 2003)

Working memory is defined as a small amount of information that can be held in the mind for cognitive tasks. (Jha et al., 2010)

Working Memory Capacity (WMC) is the mental capacity to maintain and manipulate relevant information towards a goal, without becoming distracted by irrelevant information over short periods of time. (Jha et al., 2010)

Yoga-sutras an ancient text that guides the practice of yoga today. The exact date of its creation is unknown, but has been calculated to have been created between 200 BC and 200 AD by a person named Patanjali. He traveled throughout India studying and observing the different systems of yoga that were being practiced then. He put his observations into 200 scientific principles and philosophies that provided an analysis and structure that is still regarded as one of the most comprehensive and authentic texts on yoga. (White, 2019)

Overview of Chapters

The purpose of this study was to determine if a short-term, informal program of self-guided meditation may lead to improvement in cognitive function. Chapter II is a review of literature that will provide a framework of current research studies concerning the benefits of meditation and in support of the research questions. Chapter III provides a description of the methods, procedures, and tools used to gather data for this research study. Chapter IV presents the findings of this study, and Chapter V provides a summary of the study, conclusions, and future recommendations.

CHAPTER II: REVIEW OF LITERATURE

Some cultures have been practicing meditation for centuries, and there have been many claims and assertions for the benefits of meditation. Both the practice of meditation, and the research as to its benefits, have been growing. This literature review investigates the benefits of meditation with respect to improvement of cognitive functions.

Benefits of Meditation

A variety of research studies have concluded that meditation is correlated with a wide scope of benefits including physical, psychological, and cognitive. The benefits of these meditation interventions are often found together in one study. For example, Sumpter et al. (2009) conducted a mindfulness meditation intervention on 17 female detainees in a correctional facility. The initial testing consisted of self-reporting of medical symptoms, emotional control indicators, and anxiety disorder behaviors. The study found meditation correlated with a reduction in anxiety disorders like nail-biting and difficulty sleeping, which have effect on overall mood and well-being. More importantly, the meditation participants also experienced a reduction in inappropriate aggressive behaviors after completing the seven-week program.

Singh et al. (2007) found similar results with three individuals who had a history of verbal and physical aggressive behaviors. These patients' behaviors required them to be removed from society and placed in a hospital. The intervention involved a six-week mindfulness meditation program that consisted of two sessions per day for six weeks, followed by an audio self-directed program. This meditation program guided the patients to quickly divert their rising anger responses, from an upsetting event to a neutral focus point that dissipated their anger. Following the meditation treatment program, the patients demonstrated the ability to control themselves and not respond aggressively. They were allowed to integrate back into their communities and were monitored each month for four years after the intervention. The follow up four-year assessment found no physically aggressive incidents with any of the three patients. (There were three incidents of verbal aggression by two out of the three participants; these incidents were minor and were not serious enough to be readmitted into the hospital.) The authors of this study recommended that this practice be seriously considered as an integral part of treatment for psychological issues because of its low cost and ease of implementation.

Research has been conducted in the field of psychology to assess the benefits of meditation programs that have been integrated into treatment programs. Some studies have concluded that mindfulness objectives involving awareness, concentration, and detached observation practice, have been shown to help patients become aware of their state of mind, and separate themselves from painful issues they have experienced (Lau & McMain, 2005; Myra et al., 2005). The integration of a meditation program into psychological treatment has shown decreased depression, anxiety, and anger in patients (Baer et al., 2003; Germer et al., 2005; Hayes et al., 2004; Manocha et al., 2011; Schreiner, & Malcolm, 2008; Singh et al., 2007).

In these studies, the integration of a meditation program correlated to positive impacts on physical and emotional well-being, self-regulation, and mental health. Meditation interventions of various lengths and styles have also been shown to have a positive effect on cognitive functioning (MacLean et al., 2010; Prätzlich et al., 2016; Zeidan et al., 2010)

Benefits of Meditation on Cognitive Functioning

Cognitive processes are defined as any of the mental activities that are involved in the acquisition, interpretation, storage, and use of knowledge (Benjafield et al., 2010). This encompasses a wide scope of mental activities such as attention, perception, learning, problem-solving, memory, comprehension, and reasoning. Cognitive functions such as working memory, planning, task switching, inhibitory control, and attention control are often referred to as executive functions. Meditation research has increased in the field of cognitive neuroscience for its potential positive effects on these mental functions and processes (Lutz et al., 2009). Studies that evaluate the improvement of meditation on cognitive function tend to focus on processing speed, brain wave activity, or task completion. One study by Kozasa et al. (2012) found that regular meditators have more efficient use of their brains, compared to non-meditators conducting the same mental task. Participants of the study were broken into two groups: one group had never meditated before (naïve group); and a group that had an average of eight years of meditation experience (experienced group). The researchers used two tests to measure cognitive function: the Stroop color word task (SCWT) and functional near infrared spectroscopy (fNIRS). The SCWT determines accuracy in completing a timed, mentally challenging task. The fNIRS monitors electrical activation and blood flow of the brain during activities. The results of this study showed that the experienced group were more accurate on the SCWT than the naïve group, and that they used their brains more efficiently. The naïve group required more activation

of their brains and more blood flow to certain regions of the brain than the experienced group. The naïve group did not perform as well as the experienced group on the same tests.

Benefits of Meditation Measured by Changes in Brain Structure and Activity

Some studies have shown that long-term meditation leads to structural changes in the brain (Davidson et al., 2003; Lutz et al., 2004). Davidson et al. (2003) conducted a study of 25 subjects that were tested before, right after, and four months after an eight-week MBSR program. The researchers used electroencephalography (EEG) to observe electrical brain activity in both the experimental and control group. They also used the State-Trait Anxiety Inventory test to measure individual traits and states of anxiety. The meditation group showed greater activation of the left side of their brains which are associated with adaptive responses to negative or stressful events. Individuals who show greater activation in these regions of their brains have been shown to adapt quicker to negative occurrences (Davidson et al., 2000). The meditation group also showed lowered anxiety levels than the non-meditative group.

Lutz et al. (2004) reported that certain brain-wave patterns, high-amplitude gamma frequencies in particular, coordinate and synchronize in participants during meditation. They monitored the brain-wave activities of meditators and non-meditators during states of rest, and during mental concentrative sessions. Long-time meditators had larger increases in synchronous brain-wave patterns than the non-meditators during the activities. They also reported that the meditation group had calmer brain waves (more alpha and theta brain waves) during resting states than the non-meditators. These results suggest that long-term meditators have neurologically transformed their brains through training.

Cotier et al. (2017) found through magnetic resonance imaging (MRI) that elderly people who meditated for eight weeks showed an increase in brain activity in specific regions of their

brains. These regions of their brains were less active before the meditation program began. Luders (2014) and Sun et al. (2013) found that meditation reduced the cognitive decline in elderly individuals and improved several areas of cognitive function. Three different studies found that a meditation practice showed an increase in gray-matter density and neurological changes in regions of the brain that control attention, self-regulation, and self-awareness (Dodich et al., 2019; Hölzel et al., 2011, Pagnoni & Cekic, 2007).

Benefits of Meditation Measured by Cognitive Performance Tests

A common finding within many studies of meditation involving cognitive performance is related to increased performance on attention tasks by meditators (Badart et al., 2018; Chambers et al., 2008; Jha et al., 2007; Kozasa et al. 2012; Moore, & Malinowski, 2009). Long-term meditation has been shown to benefit attention control, the exclusion of irrelevant information, working memory capacity, and anxiety control (Badart et al., 2018; Chambers et al., 2008; Chandla et al., 2013; Hasher et al., 2007; Jha, et al., 2007; Moore, & Malinowski, 2009). Tang et al. (2007) conducted a study on 40 Chinese undergraduate students who participated in what the researchers called a five-day IMBT program. This study involved an integration of Chinese tradition meditation practices, progressive-relaxation, and the MBSR program. In addition to increased attention control, their study also showed a decrease in anxiety, depression, anger, stress-related cortisol levels, and fatigue. They also reported an overall increase in positive mood scores with meditation participants.

Some studies have shown that meditation improves certain cognitive executive functions. Moore and Malinowski (2009) conducted a study with 25 experienced meditators from a Buddhist center and a control group of 25 non-meditators. All the experimental group participants had gone through a basic Buddhist six-week mindfulness course at a minimum. The

control group was 25 non-meditators. By using the d2-Concentration and Endurance Test, and the SWCT test, their study showed that meditation practices improve cognitive flexibility. Cognitive flexibility in this case involved the ability to switch between different mental tasks. The test results indicated that the meditators performed significantly better than the non-meditators on all assessments of attention control.

Rothschild et al. (2017) conducted a study to see if mindfulness meditation could improve cognitive processing speed and satisfaction with Army life. After the participants finished an eight-week course, followed by an additional 16 weeks of supervised meditation, they found that information processing speed was increased (though satisfaction with Army-life was not). Hall (1999) separated an undergraduate psychology class at Hampton University into two groups: a meditation group and a non-meditation group. Both groups' overall grade point average (GPA) did not differ at the beginning of the 16-week semester. Hall found at the end of her study that students who meditated before and after study sessions had a higher GPA than the control group who did not meditate. Mrazek et al. (2013) found a reduction in distracting thoughts, an increase in working memory capacity (WMC), and an increase in the comprehension scores on the Graduate Record Examination in 48 undergraduate students at the University of California Santa Barbara, following a two-week MBSR program.

MacLean et al. (2010) used visual discrimination of determining line-length differences, sustained attention testing, and perceptual sensitivity over time, to assess cognitive functioning. Their process involved a three-month meditation retreat, where the experienced participants meditated for five hours a day. They tested both the control group and experimental group pre-training, mid-training, and post-training. The meditation participants started showing a greater degree of discriminating the difference between the length of lines than the control group at the

mid-training assessment. The meditation group showed significantly higher discrimination ability than the control group, post-training and five months after the experiment. Their study also added that meditation improves core cognitive processing such as WMC and nonverbal intelligence.

Jha et al. (2010) also observed that mindfulness meditation training affected WMC. The study examined how mindfulness meditation training could reduce the stresses and detriments that U.S. military personnel experience during pre-deployment training. First, the study validated that the pre-deployment training cycle, and the stresses of upcoming deployments, caused a decrease in WMC. The experimental group attended an eight-week modified mindfulness-based stress reduction (MBSR) program, which was created by an officer who had extensive training in MBSR and other forms of meditation training. Their study found that the mindfulness training program reduced stress and caused improvements in WMC. They also found that more time spent in the mindfulness training correlated to greater increases in WMC.

Most of the research studies reviewed here were conducted with meditation programs lasting eight weeks or more. Research into whether a shorter-term program of mediation would indicate improvements on cognitive processing is limited. Izzetoglu et al. (2020) used the fNIRS and the SCWT to assess the improvement of attention, cognitive activity, and behavioral performance measures in 21 college students who were first-time meditators. Their findings showed improvement in cognitive processes such as attention control, memory, processing time, perception, and reasoning, after a single 22-minute meditation session. Tang et al. (2007) found that an IBMT meditation practice of five days, for 20-minute sessions per day, increased attention control and decreased stress-related cortisol. The long-term impact of these studies is unknown.

Prätzlich et al. (2016) conducted a study to see if the researchers' expectations influenced the outcome of meditation interventions. The study, conducted over a three-day period, had four groups of participants: two that meditated, and two that did not. Each of the two groups was separated into two more groups: one received positive comments about the benefits of meditation; the second group received negative comments about meditating. Interestingly, each group had performance outcomes that matched the comments and expectations they received. The positive expectation groups, both meditators and non-meditators, had increased performance, and the groups who were given negative suggestions had decreased performance. The study concluded that benefits associated with meditation were correlated more to the content of the words spoken by the researchers during the sessions than the fact of the meditation itself. However, the meditators also reported that the mediation sessions produced a heightened state of awareness, an increase in self-regulation, and a better ability to calm themselves, which the researchers indicated warranted further study.

SUMMARY

Studies of varying lengths, programs, techniques, and tasks have demonstrated the benefits of meditation on physical, emotional, and cognitive operations. Though researchers have used different methods of meditation to test its benefits, the meditative systems share a common element: the practice of controlling the direction and subject of an individual's thoughts and attention. Meditation practice leads to more efficient use of the mind, higher attention control, neurological structural changes within the brain, calmer resting states of the brain, improved cognitive processing speed, higher grade point averages, and increased working memory capacity.

CHAPTER III: METHODS AND PROCEDURES

The purpose of this study was to examine whether a self-guided five-day meditation program would improve cognitive processing speed and memory capacity as measured by online tests. The study was formed to assesses if cognitive processing speed and memory capacity test scores completed before and after five days of mediation showed improvement by statistical significance.

Chapter III details the population, instrument design, methods of data collection and statistical analysis.

Participants

The main target participants were adults 18 to 75 years old, regardless of gender. No socio-economic status requirements were required by the study. Undergraduate and graduate students were sought through a southeastern university emailing system. Adults from the corporate workforce were recruited via social/professional networking groups. Adults from the corporate workforce were required to be 18 years or older. There were no educational requirements, but those with a college degree were preferred.

Old Dominion University students (ODU subjects) and contacts of the researcher already identified through social/professional networking groups (non-ODU subjects) were the focus of efforts to recruit participants. ODU subjects enrolled in science, technology, engineering and math (STEM) Education and Professional Studies courses at the undergraduate and graduate level were the primary focus, and were contacted via email solicitation sent through the respective class professors. Other subjects were solicited through 1) networking site messaging/posts, and 2) direct emails to individuals (known to the researcher through professional networks).

Instrument Design

Two online tests were used to assess and score cognitive processing speed and working memory capacity. For cognitive processing speed, a five-minute timed online *Mental Speed Test 1* from *Psychology Today* was used. The test consisted of word and image pairs and simple mathematical equations that required a correct or incorrect button response. If the word and image matched, the participant was to select either correct or incorrect. The same response was required for simple mathematical equations that were either correct or incorrect. Response time and accuracy are recorded and assessed by the website. The website summarizes a percentage of correct responses that were provided by the participants to the researcher for analysis. To assess memory capacity, the researcher used an online test called the *Memory Test Challenge* which consisted of a series of images that appeared at timed intervals. Images that repeated required the touching of the keyboard space bar (or tapping the screen for tablets and smart-phones). Response time and accuracy recall were scored and assessed by the *Memory Loss* website test. The participants were asked to take the tests once before starting the meditation program and once again after meditating for 15 minutes a day for five days. After each test their scores were provided to the researcher by the subjects by filling in their scores on the perspective Google Form. The scores were assigned a letter-number designator, then organized on an excel spreadsheet. A paired-sample *t-test* was performed to understand the difference between the two scores.

There are a vast number of ways to meditate. For this study, the meditation method used was a simple breath-focusing technique. The instructions on the study's website directed the participant to set a timer for 15 minutes, then focus the mind on this breathing process; inhale for four seconds, hold the breath for four seconds, exhale for eight seconds, and finally hold the

exhale for four seconds. This process is repeated until the timer signals the fifteen minutes are completed. This is one of the oldest and simplest techniques for meditation which can be traced back to the yoga-sutras which were organized and recorded by Pantanjali, dated approximately around 200 BC (White, 2019). That text is still referenced for Yoga and meditation today.

Methods of Data Collection

The results of the participants' initial and post-meditation self-reported test scores were recorded on two separate Google Forms that were accessed on the study's web page. Instructions on how to complete the study and all forms necessary for the study were available on the research study's website. Google Forms recorded those entries in a response section. This data was only accessible to the study's researcher. Any identifying data of the participant was immediately converted to a number-letter identifier to keep the participants confidential throughout the study. The researcher compiled the data from the forms into an Excel *spreadsheet*.

Statistical Analysis

Two research questions were constructed for this experiment.

RQ1: Does a self-guided short-term mediation practice impact cognitive processing speed?

RQ2: Does a self-guided short-term meditation practice impact working memory?

To find the answer to these two research questions, this experiment involved an online test to measure cognitive processing speed before and after meditating for five days. The independent variable for this experiment was the initial test scores taken by the participants before beginning one week of meditating for 15 minutes each day. The dependent variable was the test scores taken by the participants after five days of meditation. To address research RQ1, cognitive processing speed, a five-minute timed online *Mental Speed Test 1* from *Psychology*

Today was used (Mental Speed Test - Version 1, n.d.).. The test consisted of word and image pairs and simple mathematical equations that required a correct or incorrect button response. If the word and image matched, the participant was to select either correct or incorrect. The same response was required for simple mathematical equations that were either correct or incorrect. Response time and accuracy are recorded and assessed by the website.

To address RQ2, memory capacity, the researcher used an online test called the *Memory Test Challenge* (Free Short Term Memory Test, 2013) which consisted of a series of images that appeared at timed intervals. Images that repeated required the touching of the keyboard space bar (or tapping the screen for tablets and smart-phones). Response time and accuracy recall were scored and assessed by the *Memory Loss* website test.

Statistical analysis was performed on the quantitative data collected from the participants submitted scores. Inferential statistics were performed using Microsoft Excel Data Analysis. The first analysis was performed to determine whether there was any change in the scores after one week of meditating. The second analysis was performed to determine whether any such difference was significant and reliable. A paired-sample equal variance *t*-test was used to determine if there was a significant difference between the mean of each of the two groups of scores (before and after meditation). A third *data screening* statistics paired-sample equal variance *t*-test calculation was done without the scores that had reached the perfect score of 100. 10 total sets of scores had reached 100, four in the mental test and six in the memory test. The reason for the removal was the total cap on the highest score possible was 100. By eliminating the scores of 100 in the second data screening calculations, potential false increases were removed.

Summary

Research has shown that formal guided meditation practices consisting of eight weeks or more impact cognitive processing speed and working memory (Badart et al., 2018; Chambers et al., 2008; Ebaid et al., 2017; Heeren, A., Van Broeck, N., & Philippot, P., 2009; Jha et al., 2007; Mrazek et al., 2013; Rothschild, et al., 2017).

This study was conducted to determine if five days of self-guided meditation practice for 15 minutes would impact cognitive processing skills or working memory. Participants took two online tests, meditated for 15 minutes a day for five days, took the two online tests again, and then self-reported their scores onto a Google Form provided by the study's main website. The data from Google Forms was then used on an Excel spreadsheet to calculate an equal variance *t-test* to present the findings.

CHAPTER IV: FINDINGS

The purpose of this study was to determine if a five-day self-guided meditation course would impact cognitive processing and working memory. 42 participants completed the study, with an average increase of; three points in the mental test and two points in the memory test scores. A paired-sample equal variance *t*-test determined there was no significant statistical difference made by the five-day meditation experiment.

Data Analysis and Results

The independent variable in this study was the meditation conducted for 15 minutes a day for five days. The dependent variable were the changes in cognitive processing speed and working memory, which were measured by the differences between the participants first pre-meditation online test scores, and the second set of test scores done after meditating for five days. Two research questions were constructed for this experiment.

RQ1: Does a self-guided short-term mediation practice impact cognitive processing speed?

RQ2: Does a self-guided short-term meditation practice impact working memory?

To address Research Question 1, the first paired-sample equal variance *t*-test included all the scores recorded. Table 1 presents the paired-sample equal variance *t*-test results that was used to test the significance of the differences between the pre-and post-meditation scores. The *Mental Test 1* had a mean of 85.44 (M = 85.44, p = 0.13). The results indicated that there was no significant difference of improvement in scores from the pre-meditation mental test to the post-meditation mental test.

Table 1

Mental Test Paired Sample t*-test equal variances with scores of 100 included.*

	Mental Test 1	*Mental Test 2*
Mean	85.44	88.85
Variance	210.65	155.38
Observations	41.00	41.00
Pooled Variance	183.02	
Hypothesized Mean Difference	0.00	
df	80.00	
t Stat	-1.14	
P(T<=t) one-tail	0.13	
t Critical one-tail	1.66	

To address research question two (RQ2) the first paired-sample equal variance *t*-test included all the scores including those participants that reached the top score of 100. Table 2 presents the paired-sample equal variance *t*-test results that were used to test the significant differences between the pre-and post-meditation scores that were submitted. The *Memory Test 1* had a mean of M = 83.1. The *Memory Test 2* had a mean of (M = 86.94, p = 0.09). The results

indicated that there was no significant difference of improvement in scores from the pre-meditation memory test, to the post-meditation memory test.

Table 2

Memory Test Paired Sample t*-test equal variances with scores of 100 included.*

	Memory Test 1	*Memory Test 2*
Mean	83.11	86.94
Variance	168.10	123.54
Observations	36.00	36.00
Pooled Variance	145.82	
Hypothesized Mean Difference	0.00	
df	70.00	
t Stat	-1.35	
P(T<=t) one-tail	0.09	
t Critical one-tail	1.67	

Data Screening

The second statistics paired-sample equal variance *t*-test calculation was done without the scores that had reached the perfect score of 100. 10 total sets of scores had reached 100, four in the mental test and six in the memory test. The reason for the removal was the highest score possible was 100, thereby providing a situation whereby measuring any growth indicated by a score of higher than 100 was not possible. By eliminating the scores of 100 in the second data screening calculations, potential false increases were removed.

To address RQ1 in relation to potential false increases due to the cap of a total score of 100, four test scores were removed from the total pool of 42 submitted scores. Table 3 presents the paired-sample equal variance *t*-test results. The *Mental Test* 1 had a mean of M= 84.32. The Mental Test 2 had a mean of (M = 87.65, p = 0.15). The results indicated that there was no significant difference of improvement in scores from the pre-meditation mental test to the post-meditation mental test.

Table 3

Mental Test *results in which the potential false increases were removed.*

	Mental test 1	*Mental Test 2*
Mean	84.32	87.65
Variance	220.95	157.35
Observations	37.00	37
Pooled Variance	189.15	
Hypothesized Mean Difference	0.00	
df	72.00	
t Stat	-1.04	
P(T<=t) one-tail	0.15	
t Critical one-tail	1.67	

To address RQ2 in relation to potential false increases due to the cap of a total score of 100, six test scores were removed from the total pool of 42 submitted scores. Table 4 presents the paired-sample equal variance *t*-test results. The *Memory Test* 1 had a mean of M = 82.77. The *Memory Test* 2 had a mean of (M = 86.57, p = 0.10). The results indicated that there was no significant difference of improvement in scores from the pre-meditation memory test to the post-meditation memory test.

Table 4

Memory Test *results in which the potential false increases were removed.*

	Memory test 1	*Memory Test 2*
Mean	82.77	86.57
Variance	168.77	122.02
Observations	35.00	35
Pooled Variance	145.39	
Hypothesized Mean Difference	0.00	
df	68.00	
t Stat	-1.32	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.67	

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine if a five-day self-guided meditation course would impact cognitive processing and working memory. All 42 participants completed the study, with an average increase in three points in the mental test and two points in the memory test scores. A paired-sample equal variance *t*-test determined there was no significant statistical difference made by the five-day meditation experiment.

Conclusions

As mentioned above, the literature reviewed generally examined the benefits of formal guided meditation programs lasting eight weeks or longer, or where the participants had years of meditation practice prior to the study (Hall, 1999; Helber et al. 2012; Jha et al., 2010; Katherine et al. 2010; Monk-Turner, 2003). Many of these long-term programs were guided by a coach or trainer for the duration of the study. Long-term meditation programs lasting eight weeks or longer have established positive physical and mental benefits of practicing meditation (Baer et al., 2003; Chung, et al., 2012; Germer et al., 2005; Hayes et al., 2004; Jha et al., 2010; Manocha et al., 2011; Schreiner, & Malcolm, 2008; Singh et al., 2007).

This five-day meditation experiment did not show any impact on cognitive processing speed or memory. Although the participants scores increased by an average of three points on the mental test and two points on the memory test, these changes were not shown to be statistically significant. These findings were inconsistent with two other short-term mediation studies done by Tang et al. (2007) and Izzetoglu et al. (2020). There were several key differences between this study and the experiment conducted in China by Tang et al. (2007). Their study integrated

several additional components. A preparation session was conducted the day before the experiment began that was guided by a certified meditation coach. The coach mentored participants in body relaxation techniques, breathing techniques, and mental imagery. The participants were following a guided meditation CD that included daily instructions and music. The coach selected the time of day and the place that the group would consistently meditate. The participants were also monitored by a trainer during each session, and a post-meditation question and answer discussion was conducted each day. The authors acknowledged the importance of having a coach monitor the sessions and provide corrective information and guidance. After each session, the trainers could answer any questions the participants may have had. These trainers monitored the participants for any body language cues exhibited during the sessions that would indicate a participant was having trouble meditating. Another note of significance was that all the participants meditated as a group each day. These authors noted the value of group dynamics facilitating the outcome of the meditation sessions. They believed this increased the efficiency of meditating, if done together in a group setting (Tang et al., 2007).

The use of a guided mediation podcast was one key difference between this study and the study conducted by Izzetoglu et al. (2020). Their study consisted of the participants sitting in a chair, taking four tests, meditating following a guided 22-minute podcast, then taking the four tests again. Their Stroop tests were done immediately after the podcast session. These authors found an increase in brain hemoglobin oxygenation and a decrease in systolic blood pressure. They found an increase in scores after the 22-minute meditation session. The technical analysis techniques of that experiment were not done in this study. The lack of a guided meditation podcast and immediate testing conducted after the meditation session could be the factors contributing to the difference in results between their experiment and this one.

Several additional factors could have affected the results of this study. The meditation sessions were not monitored as most of the more formal meditation programs were. That was the intended goal of this study, to see if a self-guided meditation program only lasting five days could impact cognitive function and memory. The lack of a coach or mentor during the meditation sessions may have affected the quality of the meditation, which in turn, could have affected the impact of meditation on these two mental functions. A guided meditation podcast or a coach may be a necessary component, especially for first-time meditators, to ensure a higher quality meditation session. Alcohol consumption, sleep quality, and other potential confounding stress factors were not monitored throughout the week of the experiment. These unmonitored factors could have also affected the outcome of the study (Beaunieux, et al., 2014; Vitiello, 1997). Sleep quality and duration were not monitored during the experiment. A lack of sleep or poor sleep quality could have been a factor in the results of the experiment (Ratcliff, 2009).

Recommendations

Future studies on the short-term effects of meditation on mental functions could benefit on having the meditation sessions controlled daily by a meditation facilitator. The validity of whether the participants actually meditated correctly for a whole week could be established with a facilitator. Alcohol consumption, sleep quality and duration, as well as external and internal stress factors should be monitored during the length of future experiments. This could reduce variables that could adversely affect the outcome of the study. A coach or program monitor may be needed to address meditation difficulties and record the factors listed above that could affect test results.

Establishing the quality of the meditation session itself through feedback devices that monitor brain-wave frequency and other electrical feedback devices could establish the level of

quality that the participant reaches during the meditation sessions. This could accurately detail who reached a meditative state and to what level and duration they maintained the session each day. This would track the authenticity of any impact on test scores that occur. The use of music while meditating could be a factor in focusing during meditation, especially for first-time meditators. This could be a variable in which future research might pursue. And lastly, future participants may need to be recruited from a formal medical treatment program or a formal guided meditation program for all these recommendations to be fully and realistically applied.

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Appendices

Appendix A- Introduction Letter

Welcome to our research study. Thank you for participating. This study is being conducted to find out if a brief meditation session consisting of five, 15-minute sessions for five days, will improve cognitive processing. You will take a few tests that take about 90 seconds each, meditate for 15 minutes for five days, fill out a quick survey after each session, and on the final day, take those tests again. This should only take about 20 minutes out of each day.

Research has shown that long-term meditation and mindfulness practices improve focus, attention and memory, the research on the effects of short-term meditation on improving cognitive processing is limited. This study will help provide information and knowledge for the benefits of short-term meditation sessions. Meditation is defined as a contemplative, self-regulatory practice that induces a state of relaxation and may produce altered states of awareness. Meditation practices tend to fall into two broad categories; an attentional concentrative focus method or an awareness-based process that involves the practitioner observing and allowing any thoughts and feelings to arise, without any judgements or analysis.

There are many techniques of mediation. It is often beneficial to experiment and find a method or technique that works best for you. For this study to be consistent, we would like you to follow the procedure we outline in the *how to meditate instructions*.

Here is the plan for your week:

1. Fill out the Consent form here.
2. Take the Pre-Training tests here, before you begin meditating.
3. Meditate every day for 15 minutes. The process to follow can be found here.
4. On the fifth day after meditating, take the Post-training tests here.
5. On the fifth day fill out the completion survey.

Appendix B- How To Meditate Instructions

How to meditate

1. Pick a consistent time. Many chose the morning after a good night's rest, before the day gets going. Evening times may not be ideal, due to a stressful, long day or fatigue from work.
2. Find a comfortable position. Sitting is often the best to prevent yourself from falling asleep. A common occurrence with first-time meditators. Keep your back upright and straight. Feet are flat on the floor, hands resting comfortably on your thighs. When you are ready, close your eyes to reduce visual distractions.
3. Set your countdown timer to 15 minutes, with a pleasant alarm to sound at the end of your session.

   Start your session by focusing on the relaxing breath exercise.
4. The *relaxing Breath* or the *4-4-8-4 (forty-four eighty-four) Breath:*

   4.1 Inhale for 4 seconds.

   4.2 Hold your breath for 4 seconds.

   4.3) Exhale for 8 seconds.

   4.4) Hold your breath for 4 seconds.

   Repeat

   You count the seconds in your head by saying "one-thousand one, one-thousand two, etc."
5. The *wandering mind*.

   In the beginning, you may be able to focus well on your breath because the technique is new. As soon as your mind becomes use to it, it may start to wander. It is very common for the mind to wander to different things, other than focusing on your breath. The key is to not get frustrated, or turn it into a forceful process. This wandering mind is not a personal defect or disability, it is a survival mechanism.

Relax, acknowledge what thought comes to mind, and return to focusing on your breathing. You will get better at focusing, the more you practice it. Some find it helpful to have a notepad and pen within arm's reach, to write down what comes into your mind, if it is important to note or remember. This way, if it is important, and you have it recorded for future reference, it will allow the mind to stop reminding you about it.

Any external distracting sounds can be used as a reminder for you to focus on the breath. Your mind may start day-dreaming, and an external sound may bring you out of that day-dream and back to the present moment.

6. Enjoy the process, feel good about it, no matter how "well" you performed it.

Appendix C- Websites for the Research Study

Meditation study website

https://sites.google.com/odu.edu/diao/home

Mental processing speed test website

https://www.psychologytoday.com/us/tests/iq/mental-speed-test-version-1

Memory test website

https://www.memorylosstest.com/free-short-term-memory-tests-online/

Appendix D- Email Solicitations to Students

Dear Professors [enter names here],

I am writing to seek participants for a short research study into whether 15 minutes of meditation per day for five days can improve memory and cognitive processing. I would be grateful if you would please forward the below to your students, and any other party you think may be interested in participating. Thank you in advance.

Dear Students:

Please see below information about how you can participate in a voluntary research study that will test whether 15 minutes of meditation per day for five days can improve memory and cognitive processing. All participants will be entered to win a **$25 Amazon Gift Card**. Your participation in this study is voluntary and anonymous. You must be 18 years or older to participate.

What will the study entail? The study participants will take two brief three-minute online tests, then meditate for 15 minutes per day for five days and repeat the tests, taking note of all test results and recording them in an online form.

How much time will it take? A few minutes to read the brief instructions, take the online tests, and record the results; and 15 minutes per day for five days for the meditation.

Where can I find out more details about the study, and how to participate? Detailed information about the study, how to participate, and where to write for further information or questions, is found here: https://sites.google.com/odu.edu/diao/home

Warmest regards,
Darrin Landry

Appendix E- Email Solicitations to Work Force Staff

Target Audience: Professional Networks of known individuals at the supervisory level

Subj: Meditation Research Study Seeks Participants (You Could Win a $25 Amazon Gift Card)

Dear Colleagues,

I am writing to seek participants for a short research study into whether 15 minutes of meditation per day for five days can improve memory and cognitive processing. I would be grateful if you would please forward the below text to those you think might be interested in participating, **on a voluntary basis**. Thank you in advance for circulating this email amongst your staff and colleagues.

Dear [staff]:

Please see below information about how you can participate in a research study that will test whether 15 minutes of meditation per day for five days can improve memory and cognitive processing. Your participation in this study is voluntary and anonymous.

All participants will be entered to win a **$25 Amazon Gift Card.** You must be 18 years or older to participate.

What will the study entail? The study participants will take two brief three-minute online tests, then meditate for 15 minutes per day for five days, then repeat the tests, taking note of all test results and recording them in an online form.

How much time will it take? A few minutes to read the brief instructions, take the online tests (each takes approximately three minutes), and record the results; and 15 minutes per day for five days for the meditation.

Where can I find out more details about the study, and how to participate? Detailed information about the study, how to participate, and where to write for further information or questions, is found here: https://sites.google.com/odu.edu/diao/home

Warmest regards,
Darrin Landry