NATURE-BASED EXPERIENCES AND MOBILE PHONES: A PILOT STUDY ON THE EFFECTS OF TEXT NOTIFICATIONS ON ATTENTION RESTORATION

by

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ABSTRACT

Today, the majority of people in the United States reside in dynamic urban environments and navigate multiple, complex situations in their daily routines. These factors of modern life often require prolonged appropriation of cognitive energy to both external stimuli and a continuous series of tasks, resulting in directed attention fatigue. Directed attention fatigue is marked by a diminishment in an individual's physiological state (alterations in neural activity), cognitive state (a decrease in motivation, reduction in the capacity to focus attention, and difficulties ignoring irrelevant information), and affective state (changes in emotional responses). The depletion of this resource results in, among other things, reduced task performance, which carries a potential for drastic, negative consequences.

Increasingly, mobile phones are having a significant impact on these states. As of 2013, an estimated 91% of adults owned a mobile phone and most frequently use it for texting. Emerging trends involve the changing relationship between user and device, as a growing number of smartphone owners exhibit behaviors of over-use, dependency, and even addiction. Given the near constant presence of mobile phones and their increasing use for personal and professional purposes, their ability to constantly place demands on directed attention is cause for concern.

Exposure to nature-rich surroundings, however, has been shown to activate alternate attentional networks, forcing the deactivation and restoration of the directed attention network. It was the purpose of this pilot study to determine to what extent directed attention is activated or deactivated in a nature-based environment when an individual is aware of the potentially distracting presence of their mobile phone. To this end, electroencephalograph recordings, a Recognition Memory Task, and the Positive and Negative Affect Schedule were utilized, with and compared across two participant groups – those completing a nature walk without a phone and those completing it while receiving text messages on their phones (though instructed not to interact with the device). Upon processing the data, no significant differences were found to exist between groups. The pilot design of this study, however, has offered insight on previously unaccounted for variables, and has the potential to inform the development of future studies.

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TABLE OF CONTENTS

LIST OF FIGURES

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CHAPTER 1

INTRODUCTION

1.1 Overview of Current Problem

According to the U.S. Census Bureau, more than 80% of the country's population resides in urban environments typically characterized by an over-saturation of stimuli, including noise pollution, light pollution, and vehicle and pedestrian movement. In addition to processing and prioritizing a near constant inundation of environmental information, individuals must also navigate multiple complex situations in domestic, occupational, and other facets of their daily lives. The demands of multitasking during such situations are typically characterized by the existence of numerous, discrete tasks, the requirement of interleaving (or alternating between tasks to maximize efficiency as opposed to completing one task at a time), interruptions, and managing tasks with differing characteristics (e.g., priority, difficulty, and time allocation) (Burgess, 2000). Prolonged appropriation of cognitive energy to both external stimuli and a complex series of tasks often leads to mental fatigue.

1.2 Directed Attention Fatigue

Defined as "a change in psychophysiological state due to sustained performance" (van der Linden, Frese, & Meijman, 2003), the abstraction of mental fatigue is more precisely identified as fatigue occurring to the neural processing pathways that comprise the directed attention network (Kaplan & Berman, 2010). The common experience of directed attention fatigue is marked by a diminishment in an individual's physiological state (alterations in neural activity), cognitive state (a decrease in motivation - particularly toward a task, a reduction in the capacity to focus attention, and difficulties ignoring irrelevant information), and affective state (changes in emotional responses) (Boksem & Tops, 2008). Physiologically, this form of fatigue is localized within the prefrontal cortex (PFC), a region of the brain in which information relays between sensory, motor, and other subcortical areas meet. These connections along with the prefrontal cortex's mechanisms for higher-order processing provide this region with the unique ability to obtain a wide variety of continuous inputs from our complex environment, mitigate and prioritize this information, and disperse biased signals to other areas of the brain so as to direct outputs that conform with accomplishing a given task (Anguera et al., 2013; Lorist, Boksem, & Ridderinkhof, 2005; Miller & Cohen, 2001).

Cognitively, the higher-order processes of the prefrontal cortex are collectively associated with the directed attention network. Directed attention is a type of task-/goal-oriented behavioral control that works by (a) prioritizing and processing sensory information relevant to achieving a current goal and (b) suppressing information that is irrelevant or incompatible with that goal (Boksem, Meijman, & Lorist, 2005). PFC higher-order processes commonly associated with directed attention include information filtering or gating, working memory, task sequencing, planning, flexibility, delayed responses, problem solving, and executive functioning. Affective states are also influenced by directed attention, as (a) even emotion-laden stimuli must compete for processing priority in the PFC and (b) an individual's ability to process and regulate their emotional responses relies on their capacity for executive functioning (Pessoa, Kastner, & Ungerleider, 2002). The physiological construction of the PFC allows for the concentration of neurological processes and functions whose incorporation contributes to the formation of the directed attention network, which is partially responsible for affective processing. The PFC and its functions, however, are a finite neural resource susceptible to fatigue if overused, leading to negative repercussions for cognitive and affective states.

1.3 Influences of Technology

Increasingly, personal electronic devices, particularly mobile phones, have begun to have a significant impact on these states. As of 2013, an estimated 91% of adults in the United States owned a cell phone (with smartphones encompassing an ever-expanding proportion of these) (Duggan, 2013). When asked about mobile phone activity, respondents most frequently reported using the text-messaging (81%) feature (Duggan, 2013). A noted emerging trend involves the changing relationship between user and device as a growing number of smartphone owners, particularly those between the ages of 18-29, mentioned being dependent on their phones for a wide variety of daily activities (Smith, 2015). Given recent shifts in usage patterns, it has become increasingly important to understand the extent to which mobile phones impact an individual's physiological, cognitive, and affective states.

1.4 Attention Restoration

In their 1989 work, Kaplan and Kaplan introduce the concept of a nature-based intervention for addressing directed attention fatigue. The authors posit that exposure to nature-rich surroundings activates alternate attentional networks, forcing the deactivation of the directed attention network and subsequently allowing it to rest. It is the purpose of this study to determine to what extent directed attention is activated or deactivated in a nature-based environment when an individual is still aware of the potentially distracting presence of their mobile phone.

1.5 Consideration of Alternate Factors

Though a sizable body of literature supports both the negative implications of the complex individual-mobile phone relationship as well as the merits of nature-based attention restoration interventions, other factors may explain the activation/deactivation of directed attention when individuals retain possession of their phones while in natural settings. The most notable of these include perceptions of safety, social dynamics, environmental incompatibility, and positive associations with mobile phones. Perceptions of safety may be either conducive to directed attention deactivation (if an individual feels comfortable and considers their surroundings to be manageable) or activation (if an individual feels uncomfortable, inadequately prepared to handle changes, disoriented, or fearful) (Staats & Hartig, 2004). Similarly, social dynamics can lead to the deactivation of directed attention (if the presence of others contributes to the perception of safety) or activation (if safety is not an issue and other individuals draw one's focus) (Staats & Hartig, 2004). When considering the environment, if an individual perceives that their surroundings are incompatible with their desired activity and behavior, they may become disengaged from it, allowing their directed attention to be captured by other stimuli or goals. Lastly, some studies have mentioned that many individuals report positive benefits associated with the use of mobile phones, including connection to social networks, feeling safe and secure, feeling less stressed due to greater organization of daily routines, and being in contact with support networks such as family and friends (Hong, Chiu, & Huang, 2012; Walsh & White, 2007). Though these reported benefits may not alleviate fatigue, it is important to note that they may suggest a disconnect between the presence of mobile phones and the depletion of directed attention.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Current Problem

2.1.1 Directed Attention Fatigue

In the past several decades, various aspects of our domestic, occupational, and general daily lives have undergone transformations that often involve greater demands on our mental faculties. Urban surroundings have become dominated by a plethora of novel and varied sounds, purposely attention-grabbing advertisements, flashing and constant sources of light, and pedestrian as well as vehicular movement. Multitasking, interacting with one or more electronic devices, and operating motor vehicles have become common daily activities for most people. In the United States, as well as in other developed countries, economies have transitioned from labor-intensive, manufacturing-based industries to research and development-driven, service-oriented, and information-based enterprises. These environmental, societal, and occupational shifts have coincided with increased reports of negative physiological, psychological, and social effects.

In a 2007 review of health-related lost productive time (LPT) in the U.S. workforce, Ricci, Chee, Lorandeau, and Berger emphasized mental fatigue as a recurrent, underlying source or contributing factor for many health conditions. Mental fatigue commonly refers to a condition induced by prolonged durations of strenuous cognitive activity requiring sustained performance efficiency (Lorist, Boksem, & Ridderinkhof, 2005). Indications of the condition can reveal themselves over long or short periods of time, as the cause of fatigue is associated with the intensity of mental exertion more so than its duration (Boksem & Tops, 2008). Daily instances of multitasking and high decision latitude responsibilities are common determinants of fatigue, as they require an individual to simultaneously perform numerous mental operations involved with information processing, evaluation, and prioritization in order to accomplish a desired goal or task. Given its extensive range of both causal sources and effects, the abstract concept of mental fatigue can be best considered in terms of a continuum (Lewis & Wessely, 1992), where the lesser end of the scale "comprises acute circumstance-based episodes that can resolve quickly after intervention such as a rest or the improvement of an environmental stressor," while the more severe end of the scale comprises symptoms of a "more chronic and disabling condition such as major depressive disorder or chronic fatigue syndrome" (Ricci et al., 2007, p 1).

Ricci and her colleagues determined that approximately 38% of the U.S. workforce experienced some level of fatigue, with 66% of these reporting lost productivity time. In similar studies, 40% of women in Sweden and 47% of employees at two organizations in England reported symptoms of varying degrees of mental fatigue (Bengtsson et al., 1987; Kellner & Sheffield, 1973). Ricci et al. (2007) also found that employees with greater decision-making responsibilities were more prone to experiencing mental fatigue than employees with fewer or less demanding decision-making responsibilities. In all, both the indirect and direct impacts of mental fatigue in the workplace were found to contribute to a loss of more than one hundred billion dollars annually for employers, most of which was due to diminished work performance as opposed to employee absence.

Ricci and her associates went on to connect mental fatigue in the work place to greater personal and social repercussions, as well, when noting:

> Fatigue may be linked to physical and psychological disorders such as anemia, chronic pain, endocrine disease (e.g., diabetes, hypothyroidism), infection, sleep disorders, depression, and anxiety. It may also be related to lifestyle factors including obesity and insufficient physical activity, environmental stressors (e.g., personal relationships) and psycho-social work characteristics (e.g., job demand, decision latitude, social support, and job strain). (Ricci et al., 2007, p. 9).

Other studies have expanded on these findings. Baker, Olson, and Morisseau (1994) determined that several workplace incidents and accidents were attributed to mental fatigue. Campagne et al. (2004) tracked changes in driver competence over a 3-hour period of time and noted that as mental fatigue increased, performance decreased while error rates increased. Marcora, Staiano, and Manning (2009) concluded that while mental fatigue does not directly impact an individual's cardiorespiratory and musculoenergetic performance during physical activity, it does impact an individual's perception of effort as well as how soon they will elect to discontinue such activities. Additional effects of mental fatigue include a resistance to continued effort on a task (Lorist et al., 2000), a reduced propensity for detail-oriented, analytic information processing (Sanders, 1998), and alterations in emotional states (Holding, 1983). Given these findings, the concept of mental fatigue can be more precisely understood as fatigue occurring to the directed attention network – a conglomeration of neural processing pathways responsible for higher-order thinking and behavioral control (Boksem & Tops, 2008).

2.1.2 Mobile Phones

The pervasiveness of personal electronic devices has compounded the issue of directed attention fatigue. In recent years, mobile phones, particularly smartphones, have become near-permanent fixtures of our lives, with ownership rates reaching approximately 90% of adults in the United States (64% of these being smartphones) (Smith, 2015). Due to substantial advances in hardware and software, smartphones are more and more relied upon to enhance their user's productivity, efficiency, social connectedness, and multitasking efforts throughout daily routines, often with negative effects (Salehan & Negahban, 2013). Similar to findings of Ricci et al. (2007) mentioned above, Thomee, Harenstam, and Hagberg (2011) reported physiological symptoms (stress, sleep disturbances, and depression) when examining the relationship between high information and communications technologies (in this case mobile phones) and mental health. Attempts at using mobile phones while driving have also been linked to potentially dangerous behaviors as well as the task overloading affiliated with directed attention fatigue (Strayer & Drews, 2007; Walsh, White, Hyde, & Watson, 2008). Since directed attention fatigue is associated with a diminished capacity for panoptic goal-oriented behavioral control and performance, it is critical to more fully understand not only emerging environmental factors that contribute to it, but also the physiological, cognitive, and affective impacts of the condition.

2.2 Impacted States

2.2.1 Physiological State

When fully developed, the prefrontal cortex (PFC) occupies approximately one-third of the human cerebral cortex, and is noted for its interconnections to other neocortical regions (Fuster, 1988; Siddiqui et al., 2008). These regions include the thalamus (a relay for sensory inputs and motor outputs), sensory systems (visual, auditory, somatic, and olfactory), various limbic formations (including the hypothalamus, amygdala, and hippocampus, which are associated with affect, motivation, and memory), and subcortical structures associated with motor control (including the basal ganglia and cerebellum in addition to the thalamus) (Banich & Compton, 2011; Fuster, 1988). These connections to sensory systems, motor systems, and subcortical structures along with the prefrontal cortex's mechanisms for higher-order processing provide this region with the unique ability to obtain a wide variety of continuous inputs from a complex environment, mitigate and prioritize this information, and disperse biased signals to other areas of the brain so as to direct outputs that conform with accomplishing a given task (Anguera et al., 2013; Lorist, Boksem, & Ridderinkhof, 2005; Miller & Cohen, 2001).

One representation through which neural processes can manifest themselves is in the form of brain waves. Theta waves, in particular, indicate a sustained application of directed attention. Most commonly observed in the midfrontal region, and therefore labeled frontal midline theta (Fmθ) (Ishihara & Yoshii, 1972), these waves (occurring between 4 -7 Hz) represent attentional activation in various mental states, including the cognitive and affective, and are associated with activities such as problem solving (Arellano & Schwab, 1950), memory encoding and retrieval (Klimesch et al., 1996), stimuli recognition (Burgess & Gruzelier, 1997), general learning (Lang et al., 1987), working memory maintenance (Jensen & Tesche, 2002), perceptual processing, and affect responses (Matsuoka, 1990). Theta oscillations have also been shown to increase relative to greater task demands (Laukka, Jarvilehto, Alexandrov, & Lindqvist, 1995; Mizuki et al., 1984). Conversely, the presence of alpha waves (8 - 14 Hz) have been associated with cortical "idling" (Pfurtscheller, 1992), indicating periods in which directed attention is not relied upon for task or goal-oriented processing and can therefore rest. Both frontal midline theta and alpha waves can be observed using hemodynamic functional imaging methods, such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), or electrophysiological recordings, such as magnetoencephalograph (MEG) and electroencephalograph (EEG).

2.2.2 Cognitive State

Generally associated with the prefrontal cortex, directed attention is a type of task-/goal-oriented behavioral control that works by (a) prioritizing and processing sensory information relevant to achieving a current goal and (b) suppressing information that is irrelevant or incompatible with that goal (Boksem, Meijman, & Lorist, 2005). A form of top-down behavioral control, it utilizes various PFC functions, including executive functioning (aspects of which included sustained attention, short-term memory tasks, inhibition of interfering stimuli, information filtering or gating processes, working memory, task sequencing, planning, flexibility, delayed responses, problem solving, emotional regulation, etc.), memory (encoding and retrieval), and gaze control (the ability to direct eye movements so as to scan one's surroundings for pertinent information)

(Siddiqui et al., 2008). Prolonged periods of sustained directed attention, however, have been associated with cognitive resource depletion and fatigue.

Studies have demonstrated that intensive performance on one or multiple complex tasks compromises an individual's performance on subsequent tasks that rely on the same cognitive functions (Van der Linden, Frese, & Meijman, 2003; Vohs & Heatherton, 2000). Symptoms of directed attention fatigue were found to include reduced flexibility in adapting strategies to changing conditions, difficulty focusing on tasks (Van der Linden et al. 2003), waning commitment or even aversion to task completion (Meijman, 2000), decreased ability to suppress distracting stimuli (Boksem et al., 2005), and an increase in performance errors (Lorist et al., 2005). Various methods have been utilized to measure changes in directed attention, including the Wisconsin Card Sorting Test (WCST), proofreading tasks, Necker Cube Pattern Control task (NCPCT), recognition memory tasks, and memory recall tasks. Similar to lab findings, the daily demands of multitasking and information processing can result in the gradual diminishment in the directed attention processes associated with monitoring and evaluating as well as regulating behavior and emotion (Lorist et al., 2005).

2.2.3 Affective State

When processing and prioritizing perceptual information, various mechanisms associated with the directed attention network are simultaneously utilized, including that of the affective significance attached to sensory events (Driver, 2001; Vuilleumier, 2005). These emotional cues assigned to objects, behaviors, and events result from a dynamic and recursive appraisal of such stimuli as they relate to an individual's values, goals, and welfare (Sander, Grandjean, & Scherer, 2005). This recurrent evaluation of internal and external inputs can best be understood as part of a complex feedback cycle in which affective and cognitive processes influence each other through both bottom-up (or sensory-driven) and top-down (behavioral regulation) mechanisms (Pessoa, Kastner, & Ungerleider, 2002). Since the PFC (and therefore the directed attention network) has a limited capacity for processing environmental information, stimuli with emotional valence possess a greater potential for outcompeting emotionally neutral stimuli for priority (bottom-up influence), while higher-order regulatory mechanisms (top-down influences) concurrently direct and redirect sensory cortices according to current goals (Taylor & Fragopanagos, 2005; Vuilleumier, 2005).

In 1998, Gross elaborated on the role of emotions in cognitive operations by introducing the consensual process model of emotion generation. Within this framework, emotional cues generated alongside stimuli undergo evaluation, trigger adaptive response tendencies, which may then experience modulation, and only then manifest an emotional response (Gross, 1999). Gross's process model emphasizes the affect state's reliance on the directed attention network, in general, and executive functioning, in particular. When directed attention resources are depleted, emotion-related behavior exhibits symptoms akin to those associated with declines in task performance. Van der Linden et al. (2003) found that when executive control is compromised, "actions are guided by more automatic processes, which are triggered by situational or external cues, even when this is inappropriate" (p. 47). They noted that in addition to diminished task performance, individuals were also prone to exhibiting behaviors such as appearing "perseverative or distractible, rigid or inappropriate, passive or impulsive, and disinhibited" (p. 47). Other studies have also documented similar outcomes for directed attention fatigue, including irritability (Kaplan, 1995), aggression (Kuo & Sullivan, 2001), withdrawal, and a hesitance to cooperate with others (Cohen & Spacapan, 1978). Popular forms of affect measurement include Diener, Emmons, and Larsen's (1985) Affective Intensity Measure (AIM), Zuckerman's (1977) Inventory of Personal Reactions (ZIPERS), and Watson, Clark, and Tellegen's (1988) Positive and Negative Affect Schedule (PANAS).

2.3 Attention Restoration

2.3.1 Background

In 1892, William James identified two types of attention, involuntary and voluntary, the latter of which S. Kaplan and R. Kaplan (1989) referred to as directed attention. As mentioned previously, directed attention is a top-down, focused effort to inhibit any stimuli detracting from a certain thought or task (Berman, Jonides, & Kaplan, 2008; Kaplan & Kaplan, 1989). Involuntary attention, by contrast, requires little to no effort, is bottom-up (or stimulus driven), and is characterized as being less goal-oriented and controlled (Kaplan & Kaplan, 1989; Kaplan & Berman, 2010). Considered to be limitless in capacity, involuntary attention requires little by way of cognitive resources as the intriguing stimuli capturing an individual's attention are sufficient enough to override the influences of less intriguing stimuli (i.e., energy is not required to suppress distractions) (Berto et al., 2010; Hartig et al., 1996). As both attentional networks cannot be drawn upon simultaneously, the engagement of one will subsequently impel the deactivation of the other. Since directed attention is a finite resource whereas involuntary attention appears to be inexhaustible, the activation/deactivation relationship between these two has significant implications for the recovery of mental fatigue caused by the overuse of directed attention.

Several methods exist for recovering directed attention, including sleep and meditation. These, however, suffer from limitations: the former may (1) be inappropriate in certain situations and (2) recovery is dependent on time allotted to this activity (which may not be sufficient among young adults); while the latter is a slowly developed discipline acquired through knowledge and practice (Kaplan & Berman, 2010). An alternative method unrestricted by such confines, however, has been proposed.

2.3.2 Attention Restoration Theory

In their 1989 work, *The Experience of Nature: A Psychological Perspective*, Kaplan and Kaplan introduce the concept of a nature-based intervention for mental fatigue, and laid out the criteria necessary for such environments to offer attention restoration opportunities. According to the authors, restoration occurs when surroundings induce involuntary attention and allow individuals to obtain the positive psychological, cognitive, and affective benefits that come from rested directed attention (Berto et al., 2010). Hartig et al. (2003) summarized the person-environment interaction necessary for the outcome of attention restoration in the following:

> According to ART [attention restoration theory], restoration from directed attention fatigue occurs with psychological distances from routine mental contents (*being away*), in conjunction with effortless, interest-driven attention (*fascination*), sustained in coherently ordered environments of substantial scope (*extent*) when the person's inclinations match the demands imposed by the environment as well as the environmental supports for intended activities (*compatibility*). (p. 110)

Recent research has supported the concept of a predisposition toward natural environments for the purposes of relieving symptoms of fatigue. Physiological recovery by exposure to nature has been documented utilizing measures of heart rate, muscle tension, systolic blood pressure, salivary cortisol, and EEG with these showing greater reductions in stress and fatigue when compared to results from those not exposed to natural environments (Aspinall et al., 2013; Hartig et al., 2003; Roe & Aspinall, 2011; Thompson et al., 2012; Ulrich, Simons, & Losito, 1991). Increases in positive affect and cognitive restoration have also been noted among participants completing a walk in a rural setting as opposed to participants completing the same task in an urban one, who exhibited adverse effects (Hartig et al., 2003; Roe & Aspinall, 2011).

Studies using preferential rating scales have found that when asked to select environments with restorative properties, participants rated urban areas with green spaces higher than strictly urban areas, but consistently rated natural settings absent of urban influences highest of all possible choices (Hartig, Korpela, Evans, & Garling, 1997; Herzog et al., 2003). Purcell, Peron, and Berto (2001) discovered similar results in comparing built to natural environments, and added that natural settings with the presence of water rated highest, suggesting support for evolutionary constructs underpinning attention restoration theory.

ART has its foundations in several conceptual perspectives, including those of arousal and overload in addition to evolution (Ulrich et al., 1991). The arousal perspective proposes that elevated levels of arousal or stress incurred from environments saturated with the characteristics of complexity, intensity, and movement may be more quickly reduced in environments low in these properties (Berlyne, 1971; Ulrich, 1991).

In a similar vein, the concept of overload states that exposure to stimuli and these environmental characteristics impose exacting demands on cognitive functions, thus compounding the negative effects of stress and disallowing any reprieve that may lead to recovery (Cohen & Spacapan, 1978). Perhaps one of the more influential constructs in the development of attention restoration theory is the evolutionary perspective, which proposes the existence of innate physiological and psychological connections humans hold with nature due to a prolonged period of evolution within natural environments (Ulrich, 1991). Advocates find support for this connection in the premise that involuntary attention requires little expenditure of cognitive resources but is receptive to quickly identifying that in nature which is interesting (Ulrich, 1991). This ability would have been necessary for survival, as what was interesting in a natural environment often was what needed to be attended to (Kaplan & Kaplan, 1989). In modern, urban environments, however, what is important and what is interesting have become incongruent (Kaplan, 1995). Man-made environments lack very many of the characteristics inherent to the settings people relate to most, while containing stimuli and attributes that are not only foreign to human sensory processes but also often occur frequently and at high intensities (Stainbrook, 1968). Recent advancements in technology, particularly personal electronic devices, have exacerbated this issue.

2.4 Impacts of Mobile Phones

Mobile phones, in particular, allow for communication free of physical or spatial restraints (Geser, 2004), increase the frequency of social communication (Igarashi, Taiki, & Yoshida, 2005), accommodate access to social networks, offer a level of safety and security, and assist with the organization and management of daily routines and activities (Walsh & White, 2007). Factors contributing to worryingly high rates of mobile phone use, however, have been related to internal motivations (such as self-identity, self-esteem improvement, the need to belong, and security) as well as external motivations (such as status among peers, interpersonal relationships, and in-group norms) (Hong, Chiu, & Huang, 2012; Walsh et al., 2010).

According to Walsh and White (2007), self-identity is, "comprised of a combination of enduring characteristics, such as internalized goals, values, moral concerns, and affective components, as well as externalized roles and behaviors" and is also "expressed by the way in which people interact with the environment" (p. 2407). The ability of mobile devices, particularly smartphones, to be prodigiously customized as a means of self-expression, and so singularly express a person's self-identity, imbue them with a great deal of value (Prentice, 1987). Stryker's (1987) role identity theory may further illuminate the complexity of the individual-mobile phone relationship. Stryker's theory suggests that when individuals receive positive reinforcement for certain behaviors, those behaviors are likely to not only be repeated but also be adopted as critical components of that individual's self-concept (Walsh & White, 2007). Given this, impulsive behavior has also been associated with the changing dynamics in mobile phone use.

Whiteside and Lynam (2001) identified four components of impulsive behavior as being: urgency ("the tendency to experience strong impulses, frequently under conditions of negative affect), premeditation ("the tendency to think and reflect on the consequences of an act before engaging in the act"), perseverance ("the ability to remain focused on a task that may be boring or difficult"), and sensation seeking ("a tendency to enjoy and pursue activities that are exciting and openness for new experiences"). Mobile phones may encourage impulsive behavior by provide individuals with an immediate outlet for sensation seeking by means of information notifications, which may influence urgency - particularly if the task at hand is associated with less reward (or less positive affect) than incoming information from the mobile device. On these grounds, Walsh and White (2007) were led to speculate that given the pervasive use of mobile phones (and current social expectations of en masse ownership), developing social norms, subjective norms, and attitudes may reflect an ever-burgeoning importance placed on the role of these devices in daily life.

Of young adults (ages 18-29) in the United States, 93% own a mobile phone (85% of these are smartphones), 81% use their mobile phones primarily for texting, and 91% of smartphone owners used the device to access social media accounts (Lenhart et al., 2010; Smith, 2015). With such elevated rates of ownership and use paired with a high-valued consideration, it is unsurprising that individuals are prone to overusing these devices. Undesirable outcomes have been identified with this use pattern, including student distraction during class (Selwyn, 2003), financial difficulties due to billing payments (Walsh & White, 2007), high-risk decision making by vehicle operators (Strayer & Drews, 2007; Walsh, White, Hyde, & Watson, 2008), and inattentional blindness - a phenomenon in which distracting stimuli, such as phones, override the influence of other stimuli regardless of how new and distinct they are (Hyman, Boss, Wise, McKenzie, & Caggiano, 2010). Problematic use has also been associated with age, low self-esteem, extroversion (Bianchi & Phillips, 2005), impulsivity (Billieux et al., 2006), high depression (Lu et al., 2011), anxiety (Hong et al., 2012), sleep disturbances (Thomee, Harenstam, & Hagberg, 2011), psychological distress (Beranuy, Oberst, Carbonell, & Chamarro, 2009), and mobile phone addiction (Ehrenberg, Juckes, White, & Walsh, 2008).

Waal and Morland (1999) characterize addiction as repetitive behaviors in which short-term satisfaction outweighs long-term implications generating a sum total of negative consequences. In addition to the aforementioned correlations to physiological, cognitive, and affective symptoms, Walsh, White, Cox, and Young (2010) note, “young people report thinking about their mobile phone when not using it, being distracted from other tasks when they have their phone with them, and prominently displaying the phone keeping it constantly in their awareness” (p. 333). Lenhart et al. (2010) elaborated on this with their finding that 67% of participants admitted to “checking their phone for messages, alerts, or calls – even when they don’t notice their phone ringing or vibrating,” while 44% of participants stated they kept their phones near their bedside so they wouldn’t miss any incoming communications. Smith (2011), pointed to further signs of regular overuse when reporting that 95% of 18-29 year olds utilize the text-messaging feature to send/receive an average of 87.7 messages per day (with a median use rate of 40 text/day noted).

In addition to the aforementioned correlations to physiological, cognitive, and affective symptoms, such a high volume of alerts and notifications produced by incoming texts, calls, emails, social media applications, etc. can add to directed attention fatigue, even if unattended. In her 2003 report, R. E. Smith investigated the effect of prospective memory on task performance. Prospective memory “refers to remembering to perform an intended action at some point in the future" (Smith, 2003, p. 347), and is characterized by the occurrence of other tasks in the interim between the creation of the intention and the point at which the intended action is performed (Smith, 2003). The author's findings indicate that engaging in prospective memory does indeed divert attentional resources from the task at hand, resulting in reduced performance on the current task. Other studies have posited similar findings, noting that task-irrelevant thoughts diminish performance on a wide array of tasks, regardless of whether the individual seems to be focusing on the task at hand (Schooler et al., 2011; Smallwood & Schooler, 2006).

Such exhibitions of extreme attachment behaviors are of great cause for concern due to the near continuous presence of an individual's mobile phone in their immediate vicinity. Even moments in daily routines that once would have afforded us time to deactivate our directed attention networks are now subject to the distractions of mobile phones, their notifications, their access to resources, and their link to social connections. Given recent and drastic shifts in modern society's perception of and relationship with technology, particularly mobile phones, it is necessary to more fully understand the impact of these devices on our physiological, cognitive, and affective health.

2.5 Consideration for Alternative Factors

Despite aforementioned research surrounding both the negative impacts of mobile phones on an individual's health as well as the positive effects of time spent in nature-laden environments, alternative factors influencing the potentials for both directed attention fatigue and restoration may exist. Staats and Hartig (2004) noted several factors that may repress any positive cognitive effects of being in a natural setting. Perceptions of safety in a given environment may be either conducive to involuntary attention (if an individual feels comfortable and considers their surroundings to be manageable) or a heightened state of directed attention (if an individual feels uncomfortable with the layout of their surroundings, inadequately prepared to handle changes in the environment, disoriented, or fearful of possible negative interactions with other people). When evaluating the presence of social elements in a natural setting, the authors found that the company of others had a positive effect on individuals when safety was considered; however, when safety was not at all considered compromised, participants preferred to interact with their surroundings alone. Another factor considered in the study was that of an incompatibility between the environment and the individual. If an individual feels as though he/she cannot engage in the behaviors they consider appropriate in a particular setting, they may become disengaged from their surroundings at which point, involuntary attention will not be activated.

Aside from environmental factors, some discrepancies concerning people's attitudes toward and relationships with their phones were noted in the literature. Despite a wide array of negative effects found to be associated with high rates of mobile phone use, negative effects, such as feeling uncomfortable and irritated, were also noted among participants for whom their mobile phones were not accessible (Park, 2005). Some studies have also mentioned that many individuals report positive benefits associated with the use of mobile phones, including connection to social networks, feeling safe and secure, feeling less stressed due to greater organization of daily routines, and being in contact with support networks such as family and friends (Hong, Chiu, & Huang, 2012; Walsh & White, 2007). Though these reported benefits may not alleviate mental fatigue, it is important to note that they may suggest a disconnect between the presence of mobile phones and the depletion of directed attention due to a perceived high reward associated with such actions and behaviors (Boksem et al., 2006).

2.6 Study Objective

Given the current literature on directed attention fatigue, personal electronic devices, and the neural benefits of time in natural environments, it was the purpose of this pilot study to determine to what extent directed attention is activated or deactivated in a nature-based environment when an individual is still aware of the potentially distracting presence of their mobile phone. It was expected that an individual exposed to periodic alerts from incoming messages and notifications would exhibit symptoms associated with the negative effects of mobile phone overuse and directed attention activation as opposed to the positive benefits of involuntary attention activation. Measures were utilized to examine three states in which directed attention activation can be observed: physiological, cognitive, and affective. Electroencephalographs (EEGs) were employed to monitor potential physiological shifts, where it was expected that elevated theta wave readings would be observed, indicating an activation of the directed attention network. A memory recall task was administered to determine to what extent the presence of an individual's mobile phone not only activated their directed attention network but also oriented their focus away from the given task and toward the new information provided by the notification stimuli. It was thought that such a distraction would generate some level of inattentional blindness, causing individuals to fail to remember objects and scenes from their surroundings. Lastly, an abbreviated Positive and Negative Affect

Schedule (PANAS) was administered with the anticipation that individuals exposed to mobile phone notifications would report elevated levels of negative affect and fatigue along with lower levels of positive affect, serenity, and attentiveness due to distraction and the incompatibility that may arise between their current environment (with its given task) and the desire to engage with their device.

Given findings in the aforementioned research, it is thought that alterations in the physiological, cognitive, and affective states identified as negative outcomes associated with directed attention fatigue and mobile phone overuse would be observed in the study's participants. Specifically, it is hypothesized that participants who are carrying and aware of their mobile phones will exhibit more pronounced theta wave activity (indicating directed attention activation), a reduced capacity for recalling information from their surroundings (indicating a diversion of cognitive resources from the task at hand to their mobile phone notifications), and lower rates of positive affect (indicating a level of unease associated with not being able to interact with their device). It is thought that alterations in these states will curtail any potentially restorative effects of natural environments.

CHAPTER 3

METHODS

3.1 Participants

For the purposes of this study, 50 individuals (25 males) were recruited. Participants ranged in age from 18 to 37, with an average of age of 25 years. Of these, 6 were excluded due to not following directions and by being subjected to confounding distractions during the exposure period. The remaining 44 participants (19 males) reported normal neurological functioning, normal or corrected-to-normal visual acuity, normal color vision, and were proficient in English. Participants were recruited primarily via four means. Flyers were posted on approved bulletin boards throughout the University of Utah campus. A freestanding display board was set near the garden-entrance doors at Red Butte Gardens with contact information for visitors. Advertisements were posted on Craigslist for the Salt Lake City area. Lastly, some participants also mentioned being recruited by word of mouth. All advertisements listed a contact e-mail address that participants were instructed to use for appointment scheduling purposes. At the completion of their appointment, participants were monetarily compensated for their time.

3.2 Location

The study was conducted on the premises of Red Butte Gardens with the permission of facility managers between the months of May and July. Red Butte Gardens is located on the north-eastern edge of the Salt Lake City limits, and resides on the periphery of the University of Utah campus, with the back of the property facing undeveloped canyon areas. The location was selected due to both its semi-isolation from a majority of the Salt Lake City urban surroundings and activities as well as its adjacent proximity to large and visually dominating areas of undeveloped land. Red Butte maintains a visitor center at the front of the property with a green house on the north end of the property. Behind the center, the property is composed of a series of vegetation-rich gardens with intermittent open, less heavily vegetated green spaces. Participants spent the entirety of their appointment (from pre-experiment preparation to post-experiment exiting questionnaires and concluding remarks) in the gardens and open spaces behind the center.

3.3 Procedure

3.3.1 Preparation

After confirming a 3-hour appointment time block with research staff via e-mail, participants were instructed to meet a member of the research staff at the garden-entry doors at the back of the Red Butte Gardens visitor center. Upon arrival, participants were taken to a designated area in one of the gardens where they were provided with a University of Utah IRB-approved consent document along with a participant information form, which included a general measure of the participant's current mood. Once completed, researchers collected the documents and began to prepare participants for wearing an EEG cap. NuPrep surface gel was applied to the skin surface to remove debris. A reference electrode was placed behind the right ear on the mastoid bone, and electrooculogram (EOG) electrodes were placed at the lateral canthi of both eyes (horizontal) and above and below the left eye (vertical) to record eye blinks for later data processing. QuickCell cellulose-based dry sponges (manufactured by Compumedics) were placed in the electrode locations of the EEG cap, which was then fitted onto the participant's head and fastened with a chinstrap. Researchers then applied a saline solution to each electrode for the purposes of expanding the sponges so they made contact with the scalp and achieved impedance below 10k Ohms. Electrode FP1 (preassigned in the cap) was used as the ground, and electrode A1 was used at the reference. The affixing of the EEG cap did not hinder or obstruct the participant's range of motion or field of view.

3.3.2 Pre-Exposure Walk Testing

Upon completing the EEG preparation and ensuring appropriate levels of impedance readings, researchers directed participants to a nearby garden location where pre-exposure EEG testing would be conducted. Participants underwent two 10-minute recording sessions with a short break in between these. Participants were temporarily relieved of electronic devices and asked (and later reminded) to remain seated, avoid moving around, and refrain from communicating with others in the area while recording was occurring. The first 10-minute period comprised of the participant observing their surroundings while the EEG was recording. After the completion of the first 10-minute session and prior to the start of the second, researchers provided participants the opportunity to have a break before preparing them for the second session. The second 10-minute period comprised of the same but with the addition of a Detection Reaction Task (DRT), which involved participants depressing a microswitch between their right thumb and forefinger as quickly and accurately as possible each time they experienced a vibration from the stimulus patch attached to their left arm. Participants were given the opportunity to practice responding to the DRT prior to the commencement of second recording session.

3.3.3 Exposure Walk

Having completed the pretesting phase, participants were sent on a 15- to 25-minute walk through Red Butte Gardens, and were instructed to follow the designated, handicap-accessible path marked by chalk arrows. Participants were randomly pre-assigned to a study condition prior to arrival. In the first condition (referred to as "No Phone"), participants were asked to continue to leave all personal electronic devices (initially surrendered before the prewalk EEG recording sessions) with the researchers for the duration of the exposure period so as to eliminate any potential for distraction from them. In the second condition (referred to as "Texting"), participants were told to keep their phone on them but not to interact with it, regardless of whether notifications and calls were coming through. Researchers then sent a series of text messages, according to a schedule, to participants during their exposure for the purpose of generating distracting stimuli. For convenience, participants continued to wear the EEG cap and external electrodes for the duration of the walk, though they were not recording data.

3.3.4 Postexposure Walk Testing

Upon completing the exposure walk, participants were led back to the garden area in which they were administered the prewalk test. Participants again sat for two 10-minute recording sessions in a format identical to the prewalk test. Afterwards, participants were administered the Recognition Memory Task, the PANAS, and an exit questionnaire, which contained questions concerning typical mobile phone use, whether or not participants interacted with their phones during the walk, and their general perceptions of the study. When these were completed, researchers removed the EEG cap and external electrodes, debriefed participants, and compensated them for their time.

3.4 Measures

3.4.1 Electroencephalography (EEG)

Electroencephalograph (EEG) data were collected and recorded using (1) NeuroScan 4.5 software on a 32-bit laptop running a Windows 7 operating system and (2) a NeuroScan 32-electrode NuAmp amplifier. The electrodes in the EEG cap were configured according the International 10-20 system (Jasper, 1958). The 10-mm diameter Ag/AgCl biopotential mastoid and facial electrodes were filled with a saline-based gel and affixed to participants' skin using adhesive electrode collars. Prior to data recording sessions, researchers ensured that impedance readings were below 10kOhms for each electrode.

The Detection Reaction Time (DRT) was utilized to verify participant alertness and task completion during recording sessions. DRT device and software were used to record participant reaction time and accuracy when presented with a stimulus, and were used in accordance with the International Organization for Standardization's (ISO) metric (ISO, 2012). A tactile stimulus patch was placed on each participant's upper left arm using medical tape, while a microswitch was attached to their right thumb. The tactile stimulus was set to vibrate at random intervals between 3-5 seconds, and participants were instructed to depress the microswitch between their thumb and forefinger when they encountered the vibrating stimuli. The stimulus was presented for a period of 1 second or until a response was received. As with the EEG data, reaction time (RT) data were recorded (with millisecond accuracy) by a Windows 7 laptop, and both stimuli and response recorded event markers in the EEG data. These event related potential (ERP) markers were later processed and used to ensure EEG files were reliable. During recording sessions in which participants were not completing the DRT, stimulus presentation markers were added to the EEG data to generate randomized epochs for processing purposes.

3.4.2 Recognition Memory Task (RMT)

The Recognition Memory Task was a slideshow consisting of 30 pictures – 15 pictures were taken from scenes along the exposure walk, while the other 15 pictures were taken from a different garden outside of the Red Butte premises or from online. Participants were instructed to select either "Yes" or "No" if they remembered seeing each scene along their walk, and were given a maximum of 20 minutes to complete the task. The rate at which pictures were viewed was solely determined by the participants, and they were allowed the opportunity to return to pictures at will.

3.4.3 Positive and Negative Affect Schedule (PANAS)

The Positive and Negative Affect Schedule (PANAS) was administered to determine how positively or negatively valenced participants perceived their exposure experience to be. The schedule was comprised of 28 different emotions (derived from an expanded from the original, 20 item PANAS), and included positive affect items (e.g., inspired, interested, at ease) and negative affect items (e.g., irritable, nervous, tired) (Crawford & Henry, 2004; Watson & Clark, 1999). Participants rated each affective item on a likert scale from 1 to 5 (with 1 being Very Slightly/Not At All, and 5 being "Extremely").

3.5 Data Analysis

3.5.1 Electroencephalography (EEG)

EEG data were filtered in NeuroScan 4.5 using a low pass filter of 50 Hz and a high pass filter set to DC with a sample A/D rate of 250 Hz. HEOG and VEOG artifacts were corrected using a high pass zero phase shift filter at 12 decibels per octave using linear regression derivation. Ocular artifact rejection techniques (Semlitsch, Anderer, Schuster, & Presslich, 1986) were used to correct the influence of blinks, and visual inspection was performed to remove any remaining artifacts. The data were then filtered with a bandpass, zero phase shift filter of 1-30 Hz at 48 decibels per octave, and epoced 1000ms before and after the onset of the event. Lastly, artifacts above and below 50 microvolts were rejected, which included less than 10% of the data.

Event related potentials (ERPs) were created using overall averages from NeuroScan in order to verify the accuracy of data processing. Once verified, the data were then converted to EEGlab, a free toolbox available for MathWorks' MATLAB processing software (Delorme & Makeig, 2004) for spectral analysis. The data were labeled and the electrode channels were reassigned for processing purposes and were then further filtered using Independent Component Analysis (ICA). After precomputing channel measures, a mean spectral measurement of theta frequency (4 to 7 Hz) was calculated by session (both pre- and postexposure walk) for each participant. These averages were compiled from the midline frontal region, a composite of the following electrodes: Fz, F3, F4, FCz, and Cz. A 2 X 2 repeated measures ANOVA was then used to compare within- and between-subjects effects of the exposure walk.

3.5.2 Recognition Memory Task (RMT)

Data for the Recognition Memory Task were analyzed using Signal Detection's Theory (Parasuraman & Davies, 1984; Swets & Green, 1963). According to this coding scheme, correct responses to pictures from the exposure walk were labeled "hits," correct responses to pictures not from the exposure walk were labeled "correct rejections," incorrect responses to pictures from the exposure walk were labeled "misses," and incorrect responses to pictures not from the exposure walk were labeled as "false alarms." A hit rate (HR) and false alarm rate (FA) were then calculated, where HR = ("hits" / 15 total pictures from the exposure walk) and FA = ("false alarms" / 15 total pictures not from the exposure walk). These values were then used to calculate an APrime value, where A' = 0.5 + [(HR – FA)(1 + HR - FA)][(4HR(1 - FA)]. Values for APrime range from .50 for chance performance to 1.0 for perfect accuracy. An independent-samples *t*-test was used to compare memory for scenes from the walk in No Phone and Texting conditions.

3.5.3 Positive and Negative Affect Schedule (PANAS)

The PANAS was analyzed by averaging participant responses. Watson and Clark (1994) organized the expanded schedule's adjectives into five categories: Positive, Negative, Attentive, Fatigue, and Serenity (Watson & Clark 1994). Participant responses were averaged by category within condition group, and a two group MANOVA used to determine significance between conditions.

CHAPTER 4

RESULTS

Data from electroencephalograph recordings (EEG), the Recognition Memory Task (RMT), and the Positive and Negative Affect Schedule (PANAS) were collected from two participant groups – those completing the exposure walk without the presence of personal electronic devices ("No Phone" condition) and those completing the exposure walk while receiving mobile phone notifications via text messages ("Texting" condition). Data from these three measures were collected to determine what impact, if any, the presence of personal electronic devices had on the physiological, cognitive, and affective states of individuals attempting to rest their directed attention network via time spent in nature-based environments. The findings per measure are listed below.

4.1 Physiological Data

EEG data were preprocessed using NeuroScan 4.5 software; the outputs then underwent spectral analysis in extension software for MATLAB's EEGlab (Wyczesany, 2015). The mean spectral power of theta frequency (4 – 7 Hz) was calculated per participant from the individual power of each of the midline frontal theta EEG channels (Fz, FCz, Cz, F3, and F4). The mean spectral power for both the pre- and postexposure walk testing was then computed from the combined average power at each channel. Four participants were removed – 2 for missing data and 2 for corrupted data files.

Mean spectral power scores were subjected to a two-way mixed analysis of variance having two levels of condition (No Phone, Texting) and two levels of time (pre-, postwalk). All effects were nonsignificant at the 0.05 significance level. The interaction between condition and time was similarly nonsignificant, Wilks' $\lambda = .995$, $F(1, 36) = .009$, $p > 0.05$, $\eta p2 = 0.005$ (Figure 4.1) indicating that changes over time did not vary by group. The main effect of condition yielded an F ratio of $F(1, 36) = .176$, $p > 0.05$, , $\eta p2 = 0.005$ indicating that the mean score was not significantly greater for Texting (M = 53.08, SD = 3.13) than for No Phone (M = 52.91, SD = 2.07). The main effect of time was nonsignificant, Wilks' $\lambda = 1.00$, $F(1, 36) = .009$, $p > 0.05$, $\eta p2 = 0.000$ indicating that the mean score was not significantly greater for Prewalk (M = 52.92, SD = 2.81) than for Postwalk (M = 52.98, SD = 2.53).

4.2 Cognitive Data

Data from the Recognition Memory Task were analyzed using an APrime value calculated using hit rates and false alarm rates, with a value range from .50 for chance performance to 1.0 for perfect accuracy. An independent-samples t-test was performed to compare memory for scenes from the walk in No Phone and Texting conditions. A significant difference was not found, $t(43) = .786$, $p > 0.05$, $d = 0.24$. The effect size ($d = 0.24$) was found to not exceed Cohen's (1988) convention for a large effect ($d = 0.80$). These results indicate that participants in the Texting condition (M = 0.78, SD = 0.097) scored only slightly lower than participants in the No Phone condition (M = 0.8, SD = 0.091) (see Figure 4.2).

4.3 Affective Data

At the end of the study, participants were administered the PANAS to complete based on their current affective state. The PANAS consisted of 28 adjectives scored on a scale of 1 (Very Slightly or Not at All) to 5 (Extremely). These adjectives were then organized into five categories: Positive, Negative, Attentive, Fatigue, and Serenity (Watson & Clark, 1994). Data from the PANAS were then calculated using a two group MANOVA, which revealed no overall significant differences between groups $F(5, 38) = 1.94$, $p > 0.05$, $\eta p2 = 0.204$. Mean scores for the affective categories are as follows: Positive was 2.93 (SE = 0.78), Negative was 1.20 (SE = 0.27), Attentiveness was 3.09 (SE = 0.68), Fatigue was 2.17 (SE = 0.80), and Serenity was 4.11 (SE = 0.63) (see Figure 4.3).

4.4 Additional Data

At the beginning of the study, participants were instructed to complete a question regarding their current general mood. An average participant general mood on a 21-point scale of -10 (Very Unpleasant) to 10 (Very Pleasant) was calculated to be 6.77 ($n = 21$). After completing the Recognition Memory Task and PANAS at the end of the study, participants completed an exiting questionnaire containing questions concerning mobile phone use, whether or not participants interacted with their phones during the walk, and overall perceptions of the study. Of those responding, one-third reported an average daily rate of 10 or less texts, 35.9% reported between 10-20 texts, and 30.8% reported more than 20 texts. All but 1 of the “Texting” participants interacted with their mobile phones during the walk, and 22.5% of the participants wrote comments indicating an enjoyment of the study and the gardens.

In analyzing the data from all three measures, findings suggest that no significant difference in physiological, cognitive, and affective states was noted between both groups. The data seem to suggest that an awareness of notification stimuli from mobile phone devices during a period of time spent in a nature-based environment did not significantly detract from the individual's overall experience. Possible explanations for these findings are discussed in the following chapter.

Prewalk Testing All Conditions	Postwalk Testing No Phone Condition	Postwalk Testing Texting Condition	

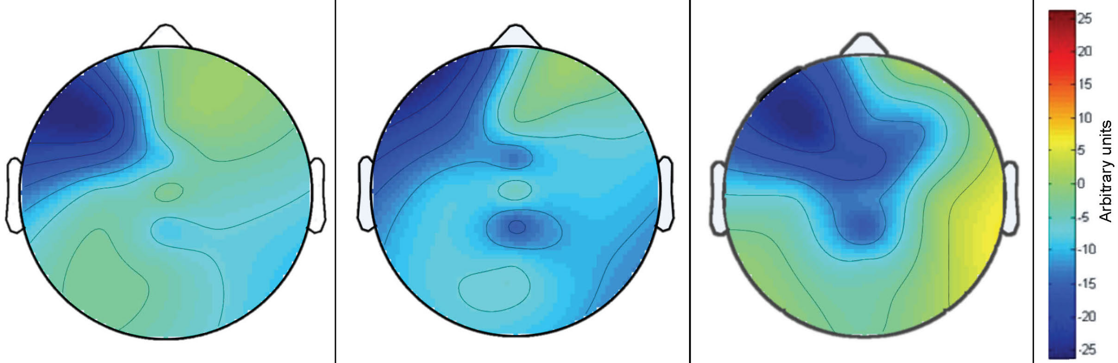

Figure 4.1 – Spectral Maps

Figure 4.1 displays the average spectral activity across the scalp for the Postwalk No Phone and Texting conditions as compared to aggregate Prewalk activity.

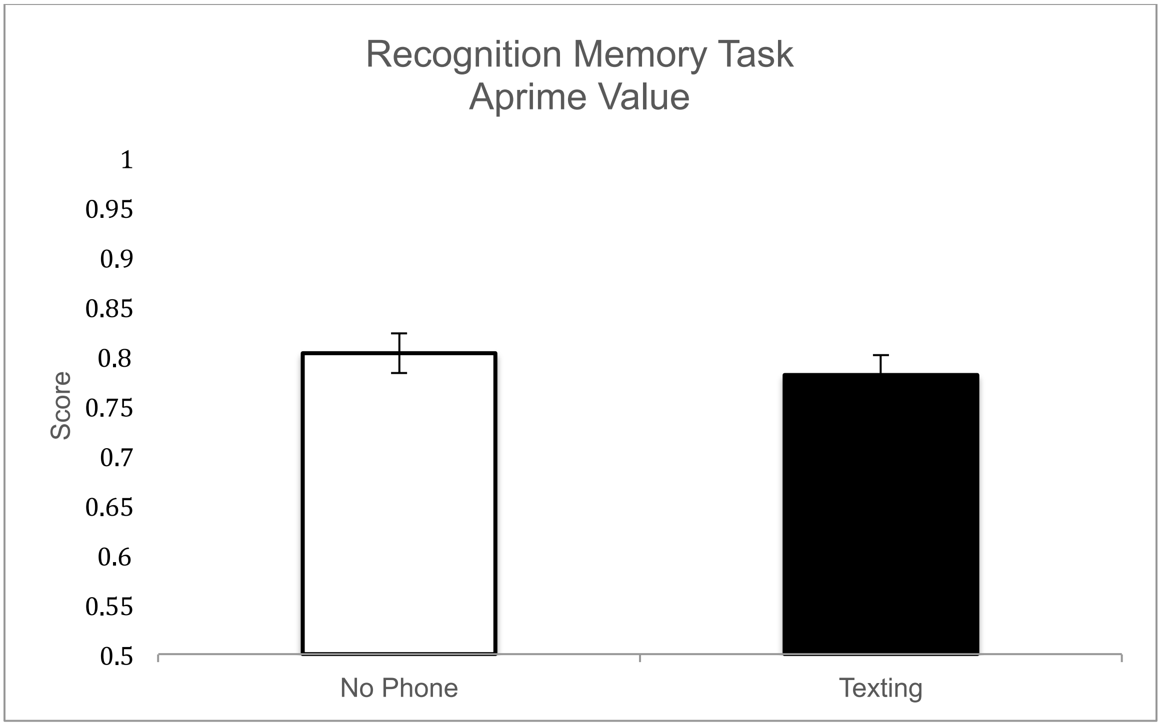

Figure 4.2 – Recognition Memory Task APrime Comparison

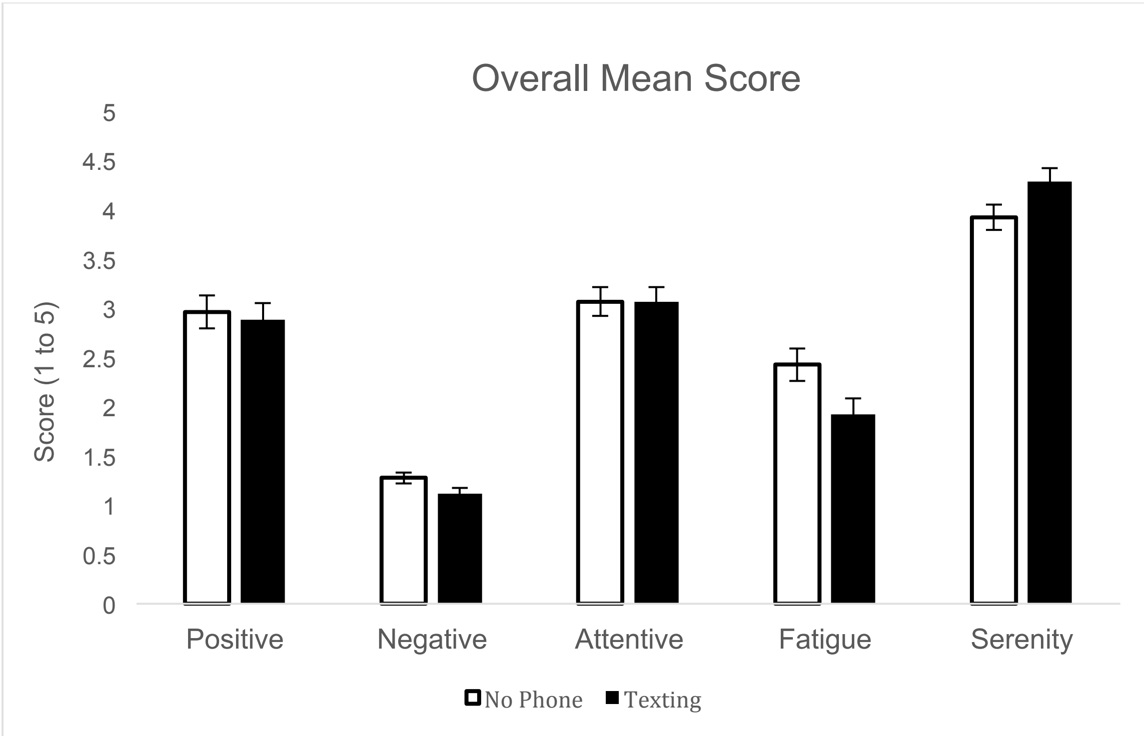

Figure 4.3 – PANAS Category Scores Compared by Condition

CHAPTER 5

DISCUSSION

5.1 Test of Hypothesis

The purpose of this pilot study was to determine to what extent directed attention is activated or deactivated in a nature-based environment when an individual is still aware of the potentially distracting presence of their mobile phone. It was hypothesized that an activation of directed attention would be noticeable across three measures: electroencephalograph recordings (for physiological effects), Recognition Memory Task results (for cognitive effects), and PANAS self-reports (for affective effects). It was expected that EEG recordings would display higher levels of theta (indicative of higher-order and task-oriented information processing in the prefrontal cortex) among participants exposed to text messaging induced stimuli during the exposure walk than among participants completing the walk without the presence of their phone. It was also expected that participants carrying their mobile phones would score lower on the RMT as well as the PANAS, indicating some degree of inattentional blindness as well as negative affect due to the presence of a distraction that was seemingly incongruent with the purpose of their designated activity. However, for these data, no significant differences were found between groups across all three measures.

5.2 Potential Alternate Explanations

Several factors may have contributed to these findings. Firstly, physiological data collection may have been limited by temporal constraints due to considerations surrounding the utilization of sensitive electroencephalograph recording devices. EEG recordings were not taken during the exposure walk due to the excessive amount of "noise" that would have been generated from physical movement as opposed to neural activity. Studies utilizing event related potential (ERP) measures, however, have demonstrated the immediacy of stimuli impact on neural processes, which often noticeably occur within seconds of the stimulus event (Boksem et al., 2005; Duncan-Johnson & Donchin, 1977; Yordanova & Kolev, 1998). Given the time delay between texting stimuli and the postexposure walk EEG recording sessions, it is possible that any neural effect induced by the acknowledgment of such stimuli may have abated to an extent that the EEG recordings would not have reflected any changes in the prefrontal cortex.

Cognitive measures seem to also suggest that no longer-term effect of directed attention activation due to distracting stimuli remained, despite the extreme likelihood that any tactile and/or auditory notifications from the texts may have generated an immediate information processing response in the prefrontal cortex. The closeness in scores between groups on the Recognition Memory Task suggests that participants carrying their mobile phones were not distracted to the extent that they might experience inattentional blindness, even though all but one of the participants did physically interact with their devices to check received texts.

There are two possible explanations for a lack of difference in RMT scores between groups. Due to the fact that most participants completed the route through the garden twice in order to fulfill a minimum requirement for time spent on the exposure walk, multiple viewings of the scenes depicted in the photos may have provided for improved recognition performance among participants receiving texting stimuli that may not have occurred had they only completed the route once. Additionally, though the attentional cost of receiving a mobile phone notification has been associated with reduced task performance due to a reallocation of directed attention resources (Stothart et al., 2015), shifts in motivation may account for similarities in the RMT scores as mobile phone notifications may have been assigned a lower priority in favor of awareness of more interesting environmental surroundings.

Similarities in affective scores on the PANAS may also be attributed to shifts in motivation. Gross' (1999) consensual process model of emotion generation suggests that both stimuli and the emotional components ascribed them undergo evaluation and prioritization when processed as sensory inputs. If emotional cues are determined to be incompatible with a present goal, they may be subjected to a declivity in priority (Sander et al., 2005). In this study, it is thought that the distracting stimuli of incoming mobile phone notifications may not have had sufficient emotional coding to override participant motivation for the task at hand. Though many studies have noted a rise in mobile phone addiction and its influence on behavioral patterns, it is possible that the conditions of this study created a situation in which participants were less inclined toward impulsive behaviors associated with addiction. Whiteside and Lynam (2001) identified four components of impulsive behavior: urgency ("the tendency to experience strong impulses, frequently under conditions of negative affect), premeditation ("the tendency to think and reflect on the consequences of an act before engaging in the act"), perseverance ("the ability to remain focused on a task that may be boring or difficult"), and sensation seeking ("a tendency to enjoy and pursue activities that are exciting and openness for new experiences").

It is plausible that participation in the study negated a need for perseverance while fulfilling the desire for sensation seeking given written comments subjects provided regarding their enjoyment of and interest in the study as well as Red Butte Gardens. Similarly, the short duration of the study, instructions to refrain from engaging with personal electronic devices, and the knowledge of monetary compensation coupled with the aforementioned novelty of the experience may have influenced the formation of a premeditated aversion within participants toward interacting with their mobile phones, thus making them more comfortable with allowing text message stimuli to have a low priority and subsequently reducing any activation of prospective memory within the directed attention network. The final component of impulsive behavior, that of urgency, may be accounted for when considering initial reports of mood. As stated previously, participants scored themselves relatively high (an average of 6.77 on a scale from -10 to 10) when considering the general state of their current mood. Given the proposed rationalization for the lack of influence from the other three components of impulsive behavior and given that urgency is strongly associated with negative affect, the self-reported positive affect existing both before and during the study across participant groups may account for similarities in PANAS and RMT scores. In all, it seems as though duration, novelty, and preexisting affect may have been influencing factors in participant motivation and prioritization. Possible adjustments made in these two schemas may account for aberrant shifts in cognitive processes as well as affective perceptions that had not been previously accounted for.

In addition to temporal complications in physiological data collection as well as the possibility of unforeseen internal factors influencing cognitive and affective results, alternative factors mentioned in previous sections were also considered as possible explanations for the results. It was thought that perceptions of environmental and social safety, incompatibility between the environment and the individual, and positive benefits associated with mobile phones (increased perceptions of safety, connection to social network, etc.) may have an influence on the study's findings. Staats and Hartig (2004) reported on the importance of perceived levels of safety in environments where attention restoration was an objective. Evaluations of acceptable levels of safety involve an individual's assessments of, among other things, their ability to navigate a particular environment, adapt to anticipated changes in that environment, easily observe an expansive amount of their surroundings, access resources in case of an emergency, and not feel threatened or insecure due to the presence of other people.

Participants completed the study during daylight hours in a built environment with handicap accessible paths, access to multiple facilities, and within proximal distance of garden and research staff. Participants were also made aware that they could terminate their involvement in the study at any time. Garden patrons were likewise made aware of the study and asked to refrain from interfering with or approaching participants. Furthermore, PANAS results showed a high level of Serenity ($M = 4.11$), indicating participants likely not only felt comfortable in the gardens but also found it compatible with their current task. Due to a reasonably high level of environmental and social safety provided by the study's location as well as its compatibility with the study's design, it is possible that participants felt at ease enough to not be reliant on their mobile phones for assistance or as an added measure of security. It is also possible that stimuli from text notifications may have reminded participants of the immediacy of their social network, which may have, in turn, improved their affective state as opposed to causing feelings of anxiety associated with delays in providing a response. If these were, indeed, factors influencing the study, they could explain higher than anticipated reports of positive as opposed to negative affect as well as low levels of distraction among participants receiving texting notifications, despite instructions to abstain from physically interacting with the device.

5.3 Limitations

Due to the nature of this study, several limitations were encountered. In being situated in an outdoor, public location, various factors (such as weather, sun exposure, the presence of other people, and noise from construction projects in the gardens) proved difficult to control for. The gardens were chosen due to their location on the periphery of the city, their densely vegetated grounds, and their ability to provide a safe space for participants, but they cannot afford the same experience as that which would be encountered in a truly natural environment. Participants were also required to own a mobile phone and arrange for their own transportation to the study site. Being as the overwhelming majority of young adults targeted for this study already possess mobile phones and that public transportation services operate within a short walking distance of Red Butte Gardens, these were not considered imposing barriers to participation.

5.4 Implications for Future Research

Given the findings and potential confounds of this pilot study, new insights can inform the development of future studies. In matters concerning physiological data collection, design alterations may provide a more acute comparison between pre- and postexposure walk electroencephalograph recordings. It is proposed that a baseline (pre-exposure walk) recording be taken in a controlled, non-nature based environment. Since pre-exposure walk recordings were taken in a nature-based environment, the baseline data may have captured early stages of the effects of attention restoration on the directed attention network. Additionally, applying the element of text notifications to the EEG recording session while in a natural environment may allow for a more accurate understanding of what immediate and longer-term impact, if any, receiving such a notification has on the directed attention network. In considering the cognitive measures taken, a longer route allowing for each participant to spend approximately 20 minutes on a nature walk while only completing one loop may provide for Recognition Memory Task results that more accurately reflect each participant's level of attentiveness to their surroundings.

Other considerations may be useful for the design of future studies, as well. A limitation of this study was the environment itself. A setting more devoid of built structures, urban sounds, and other people may aid in the development of a clearer picture of how notifications from mobile phones alone influence activation of the directed attention network. If future research is conducted in more natural environments, survey questions concerning the participant's level of comfort and perceived level of safety in such a setting my help to account for any shifts in perceptions of need or dependence on one's mobile phone due to one's surroundings. This information may also offer insight as to whether or not individuals experiencing directed attention fatigue would consider a nature-based environment as a possible outlet for attention recovery. Furthermore, in addition to affective measures, such as the PANAS, behavioral measures, such as the UPPS Impulsive Behavior Scale (Van der Linden et al., 2006) or the Mobile Phone Addiction Scale (MPAS) (Hong et al., 2012), may help inform how an individual's relationship with their mobile phone impacts their experience in nature when attention restoration is the main reason for entering a natural environment.

5.5 Conclusion

In light of both the inconclusive findings of this pilot study as well as the significant findings of other studies mentioned in this paper, further research is necessary to more fully understand the effects of the presence of personal electronic devices on individuals attempting to rest their directed attention network via time spent in nature based environments. Ample evidence exists for the benefits of time spent in nature on restoring a depleted directed attention network. This pilot study was unable to further inform our understanding of factors that may impact restoration, such as personal electronic devices, but it may provide for improvements in future studies.

APPENDIX A

PARTICIPANT CONSENT FORM

Consent Document

BACKGROUND

You are being invited to take part in a research study on the influence of technology when exposed to nature. Being exposed to nature has restorative benefits that have been seen in a variety of settings. In this study we will examine your brainwave activity (Electroencephalographic (EEG) signals) while completing the task. Before you decide to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Ask the experimenter if there is anything that is not clear or if you would like more information. Please take the time to decide whether or not you would like to volunteer to take part in this research study.

The present study involves research concerning the activation of neural substrates involved in attention. Previous studies have shown that when a person is exposed to nature, they perform better on tests that measure attention and other cognitive resources. This research is being conducted in order to better understand how distraction through technology impacts these restorative effects of attention.

STUDY PROCEDURE

The entire experiment consists of one session that will last approximately 3 hours without including breaks. This total time includes consent, electrode application, two twenty-minute segments sitting in nature, a twenty-minute walk, a recall memory task, questionnaires, and electrode removal.

We will be measuring your brain's electrical activity (i.e., Electroencephalographic (EEG) signals). We do this by attaching surface EEG electrodes to your head. The EEG electrode application procedure involves cleaning the scalp locations with alcohol and adhering each electrode to the scalp location with Grass electrode cream (a water soluble paste which provides a good contact between the surface of the skin and the electrode).

You will be required to walk on a designated path through Red Butte Gardens. You may also be required to hold a conversation on a cell-phone during this walk. The conversation is not limited to a topic, but must be at least the duration of the walk.

RISKS

The risks of this study are minimal. For example, you may get a little fatigued mentally or physically from the length of the study and the walk. However, we hope to offset this minimal risk by giving you breaks as needed throughout the course of the experiment. There is a chance that you also may experience some discomfort with the recording electrodes that will be attached to your head. There may also be risks from walking in Red Butte Gardens and risks that we do not know about.

BENEFITS

There are no direct benefits to you from your taking part in this study. This study may provide information to increase scientific understanding about the neural make-up of individual differences in different types of cognitive control.

CONFIDENTIALITY

All information that is collected about you during the course of the research will be kept strictly confidential. Specifically, all paperwork and all data will be kept in a locked filing cabinet or on a password protected computer in the laboratory/offices of the PI, Rachel Hopman. Only the PI and her research team will have access to this information. Portions of the data collected in this experiment may be presented at conference or published in a scientific journal. If this is the case, identifiers will be removed from the data in these presentations or publications. The data will be kept on record for at least five years after publication of all technical documents or until the PI and her research team deem it appropriate due to ongoing research.

PERSON TO CONTACT

If you have questions, complaints, or concerns about this study, or if you think you may have been injured from being in this study, you may contact the Principal Investigator, Rachel Hopman, at rachelhopman@gmail.com. Any and all matters will be looked into by the PI and a response will be given in a timely manner.

Institutional Review Board: Contact the Institutional Review Board (IRB) if you have questions regarding your rights as a research participant. Also, contact the IRB if you have questions, complaints or concerns which you do not feel you can discuss with the investigator. The University of Utah IRB may be reached by phone at (801) 581-3655 or by e-mail at irb@hsc.utah.edu.

Research Participant Advocate: You may also contact the Research Participant Advocate (RPA) by phone at (801) 581-3803 or by email at participant.advocate@hsc.utah.edu.

VOLUNTARY PARTICIPATION

It is up to you to decide whether to take part in this study. Refusal to participate or the decision to withdraw from this research will involve no penalty or loss of benefits to which you are otherwise entitled. This will not affect the relationship you have with the investigator.

COSTS AND COMPENSATION TO PARTICIPANTS

There will be no additional costs incurred upon you as part of the research study. You will be compensated with $15.00 per hour for your participation (depending upon whether you are able to complete today's testing session in its entirety) prorated, based on the duration of the study.

CONSENT

By signing this consent form, I confirm I have read the information in this consent form and have had the opportunity to ask questions. I will be given a signed copy of this consent form. I voluntarily agree to take part in this study.

____
Printed Name of Participant

____________________________________ ______________________
Signature of Participant Date

____
Printed Name of Person Obtaining Consent

____________________________________ ______________________
Signature of Person Obtaining Consent Date

APPENDIX B

PARTICIPANT INFORMATION FORM

Participant Information Form

Participant ID: ________
Date: ________
Condition: ________

Name: ____________________________________

uID: ______________________________________

Email: ____________________________________

Cell Number: ______________________________

Date of Birth: _____________________________

Gender:
- [ ] Male
- [ ] Female
- [ ] Transgender
- [ ] Other

Handedness:
- [ ] Left
- [ ] Right
- [ ] Ambidextrous

Have you had your normal amount of caffeine today?
- [ ] Yes
- [ ] No

Did you get a normal amount of sleep last night?
- [ ] Yes
- [ ] No

How many alcoholic drinks have you consumed in the past 24 hours?
- [ ] None
- [ ] 1 to 3
- [ ] 4 to 7
- [ ] 8+

Have you ever had an injury in the last 2 years that has caused you to lose consciousness?
- [ ] Yes
- [ ] No

OVER >

Do you have any neurological disorders?
[ ] Yes
[ ] No

If you answered "yes" to the previous question, please explain:
____
____
____
____

How often do you talk on your cell phone each day?
[ ] 0 to 1 hours
[ ] 1 to 3 hours
[ ] 3 to 5 hours
[ ] more than 5 hours

About how many texts do you send and receive each day?
[ ] 0-5 texts sent and received
[ ] 6-10 texts sent and received
[ ] 10-20 texts sent and received
[ ] more than 20 texts sent and received

Do you have corrected vision?
[ ] Yes
[ ] No

Overall, my mood is:
Very Unpleasant *Very Pleasant*
(-10) (-9) (-8) (-7) (-6) (-5) (-4) (-3) (-2) (-1) (0) (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)

Is there anything that might cause you to perform better or worse than normal in the task today that we should be aware of?
[ ] Yes
[ ] No

If you answered "yes" to the previous question, please explain:
____
____
____
____

Thank you!

APPENDIX C

RECOGNITION MEMORY TASK FORM

Participant________ Condition________ Slideshow________

SLIDESHOW QUESTIONAIRRE

Did you see this scene on your walk through Red Butte Gardens today?

Slide #

1	YES	NO	16	YES	NO
2	YES	NO	17	YES	NO
3	YES	NO	18	YES	NO
4	YES	NO	19	YES	NO
5	YES	NO	20	YES	NO
6	YES	NO	21	YES	NO
7	YES	NO	22	YES	NO
8	YES	NO	23	YES	NO
9	YES	NO	24	YES	NO
10	YES	NO	25	YES	NO
11	YES	NO	26	YES	NO
12	YES	NO	27	YES	NO
13	YES	NO	28	YES	NO
14	YES	NO	29	YES	NO
15	YES	NO	30	YES	NO

APPENDIX D

POSITIVE AND NEGATIVE AFFECT SCHEDULE

Participant ID:	________
Date:	________
Condition:	________

The PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way right now, that is, in the present moment. Use the following scale to record your answers.

1 very slightly or not at all	2 a little	3 moderately	4 quite a bit	5 extremely

_______ irritable	_____ interested	_______ attentive
_______ alert	_____ at ease	_______ hostile
_______ ashamed	_____ excited	_______ sleepy
_______ drowsy	_____ upset	_______ distressed
_______ nervous	_____ strong	_______ proud
_______ determined	_____ calm	_______ guilty
_______ inspired	_____ scared	_______ relaxed
_______ jittery	_____ concentrating	_______ active
_______ tired	_____ enthusiastic	_______ sluggish
_______ afraid		

APPENDIX E

EXIT QUESTIONNAIRE

Red Butte Study – Exit Questionnaire

Participant ID: __________
Date: __________
Condition: __________

1. Have you been to Red Butte before?
Yes No

2. How much did you pay attention to your walk?
Little attention 1 2 3 4 5 6 7 A lot of attention

3. Was it more or less than attention than you are used to?
Less attention 1 2 3 4 5 6 7 More attention

4. Did the walk feel too rushed or too slow?
Too rushed 1 2 3 4 5 6 7 Too slow

5. Did the walk feel too short or too long?
Too short 1 2 3 4 5 6 7 Too long

6. Did the rate of vibrations feel too slow or too rushed?
Too slow 1 2 3 4 5 6 7 Too rushed

7. How successful were you in accomplishing what you were asked to do?
Not successful 1 2 3 4 5 6 7 Very successful

8. How often do you take walk in nature?
Never 1 2 3 4 5 6 7 Often

9. How often do you use a cell-phone?
Never 1 2 3 4 5 6 7 Often

10. How often do you use a cell-phone to text?
Never 1 2 3 4 5 6 7 Often

11. How much did you use your cell-phone during this walk? (N/A)
Not that much 1 2 3 4 5 6 7 The whole time

12. Do you have any prior knowledge of the attention restoration theory?
Yes No

7. Do you have any additional comments?

APPENDIX F

DEBRIEFING FORM

Participant ID:	________
Date:	________

Debriefing Form

The purpose of this study was to measure differences in electroencephalography (EEG) recordings. More specifically, we are using EEG to measure the interaction between nature and attention. The Attention Restoration Theory suggests that cognitive resources such as attention can be restored when a person is exposed to nature. These restorative effects have been measured in a variety of settings to determine which aspects of nature facilitates this effect. Changes in the brain are expected when using technology to distract a person from gaining these restorative effects. We are measuring the activation of the midline frontal theta, an EEG measurement depicted using spectral analysis. We hypothesize that this activation, which is known for reflecting attention, will be increased when exposed to nature for extended periods of time compared to when exposed to outdoors or lab environments.

This research is important because it uses neuroimaging to record the previously studied effects of nature on attention, as well as the effects of exposure to nature. This study is a part of a larger sequence studying attention and technology in nature.

If you would like to learn more about this topic, please refer to the following publications:

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology (15) 3, 169-182.

Tennessen, C. M. & Cimprich, B. (1995). Views to Nature: Effects on Attention. Journal of Environmental Psychology (15) 1, 77-85.

If you have any further questions, please contact the person conducting this study at appliedcoglabutah@gmail.com

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