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Comparison of psychological states of runners within urban and rural environments

Christian Demastus
University of Tennessee at Chattanooga, christiandemastus@yahoo.com

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Christian Demastus

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Dr. Andrew Bailey	Dr. Eric Hungenberg
UC Foundation Assistant Professor of Health and Human Performance Thesis Director	Assistant Professor of Health and Human Performance Department Examiner

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Abstract

With the research on persons health and well being increasing within the past years, new questions have emerged on if certain environments can also benefit along with exercise. This study looked at the different psychological states of endurance runners as they run in urban environments and transition into rural settings. The results of this study showed significant differences between urban and rural environments. Also showed increased focus going downhill in nature and greater inward attention while moving uphill in nature. With the findings from this study, it explains why runners choose to run or train where they do.

Acknowledgement

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Introduction

Physical activity has been well documented to have both physical and mental health benefits (Vetrovsky, Tomas et al., 2017). Some research has shown that a particular environment where the physical activity is being performed may be just as beneficial (Thompson Coon et al, 2011). As constructed, this is insinuating that a particular environment is as beneficial as physical activity. Natural environments, in opposition to built environments, have an abundance of positive effects on physical and mental health, including: increases physical activity and caloric expenditure, fewer depressive indicators, reductions in myopathy, lower stress levels and increased feelings of accomplishment, (Brusonni et al., 2015; French et al., 2013; Grahn, & Stigsdotter, 2003). Built environments, with increased rates of distraction and mental anguish associated with urbanized areas, have been shown to possibly play a part in mental and physical health disorders (Prince et al., 2007; Galea et al., 2005). It's been reported that brief and simple interactions with nature can increase cognitive control (Berman et al., 2008).

While past research has well documented the effects natural environments have on mental well being, advances in technology have allowed for the chance to comprehend where those results are created. Lately, portable EEG scanners have been used to demonstrate how green spaces reduce stress response and levels of frustration (Aspinall et al., 2013). Another study found that participants walking in outdoor environments entered a more meditative state than those who walked indoors (Bailey et at., 2017). With this knowledge, we utilized portable EEG's to track differences in brainwaves of endurance runners as they run through urban and natural settings to track focus,

meditative, and anxious mental state differences between the built and natural environments while exercising. A better cognizance of how a variety of environments impact the mental states of endurance runners could provide support for why athletes choose to train or exercise where they choose. For this study, our purpose was to investigate mental states of endurance runners as they run through urban and natural environments and their effects of mental focus, anxiety and meditative states by using mobile EEG's.

Literature Review

Natural and Built Environments

Performing exercises throughout life have a great deal of benefits that come along with it. A couple studies have shown that running and walking can induce a relaxed state of mind, evidenced by increased alpha brain waves post workout (Schneider et al., 2009; Woo et al., 2009). Other studies have shown that individuals performing moderate intensity exercises for 150 minutes a week extended their longevity, decreased their risk of chronic diseases, and maintained function and health into old age (Blair & Morris, 2009). A study reported that college students who performed vigorous activity were less likely to have poor mental health and lower perceived stress than other students who did not participate in vigorous activity (Vankim & Nelson, 2013).

Physical activity in any capacity is beneficial, but the environments on which the physical activity is carried out can profoundly influence immediate and long-term effects. For instance, countless studies have promoted engagement in activities executed outdoors over those done in built environments; Exercising outdoors has been shown to decrease depression, anxiety, anger, and frustration, while increasing energy and giving rise to

greater feelings of revitalization and positive engagement (Pasanen et al., 2014; Mitchell, 2013; Thompson Coon et al., 2011).

Attention Restoration Theory

The Attention Restoration Theory (ART) has explicated the effects that natural environments play in a person's mental health and well-being. One study found that children with ADHD who spent 20 minutes in a park setting showed elevated attention performance than in other settings (Taylor and Kuo, 2009). Another study by Berman and collegues, found the same positive effects of park space for adults, without ADHD, when performing tasks for attention (Berman et al., 2008). Studies have even shown the indirect effects of nature on mental states; such as the study performed by Tennessen and Cimprich (1995), which showed that college students with views of nature from their dormitories performed better on tests than those who did not have a view of nature.

In agreement with ART, studies have shown that exercising in nature is associated with greater potential for mental restoration, affective responses that may lead to increased intentions to exercise, and elevated exercise behavior (Calogiuri et al., 2015). Having access to healing-restorative environments may influence one's perception of their health, satisfaction, and the quality of the environment they live in (Berto. 2007). Norling and colleagues (2010) showed that high intensity running significantly restored attention than a resting control group. Another study showed that individuals who walked for 30 minutes performed significantly better on a Stroop Test with the outdoor environment providing an added positive effect over walking indoors (Bailey et al., 2017).

Psychophysiology

Numerous studies have utilized mobile EEGs for research purposes to see mechanisms happening in the brain. A study conducted in 2015 by Aspinall and colleagues, used mobile EEGs to show mental states as participants moved from green space to urban areas. They found that individuals had lower frustration, engagement and arousal and higher meditation when moving into green space. Many projects have used EEGs before and after activities along with survey-based data. For this research, we will be using mobile EEGs to trace emotional states while runner's transition from urban to a rural environment. While natural environments have been shown to benefit mental health, certain mechanisms of physiology are beneficial, as well. Numerous studies have been conducted using various methods to measure electrical differences throughout the body that could impact performance. EEGs have been used to examine left-hemispheric and right-hemispheric activity on precision marksman when taking a shot (Hartfied et al., 1984).

Heart rate variability (HRV) has also been identified as a key indicator of psychological well-being. Studies have shown that changes in HRV are directly related to volume and intensity of exercise, as athletes who showed greater physical exertion also had largest decrease in HRV (Earnest et al., 2004). High frequency HRV has been shown to cause stress induced sleep disturbances, emotional strain and pressure (Jonsson, 2007; Nickel et al., 2003). Gavrilova (2016) found that a decrease in HRV is a pathogenic component of arrhythmias that could be life threatening. HRV can also be affected by altitude and elevation. A study by Boos and his colleagues (2017), suggested that hypoxia and high-altitude lead to a reduction in HRV with a decrease in parasympathetic activity and increase in sympathetic activity. Leisure time physical activity (LTPA) has also been

linked to various psychological improvements. One study showed that LTPA in adults with high levels of loneliness showed improved levels of optimism, life satisfaction, positive affect, and psychological well-being (Kim et al, 2017). Not only does LTPA improve health mentally but physically as well. One study showed that individuals who performed moderate-to-vigorous LTPA revealed lower visceral adipose tissue areas and suggested that LTPA can reduce cardiometabolic disease risk for individuals with chronic spinal cord injuries (Citation?). As been shown in numerous studies, the body's physiological responses to activity can lead to healthier person both mentally and physically.

Methods

This study comprised of 19 adults from the southeastern United States. Casual participants were recruited from a local track club to assist with the study designs ability to control for fitness as a potential spurious effect. Participants were required to run approximately 6.6 miles (10k) through an urban and rural trail located in Chattanooga, Tennessee. No incentives were offered to the participants and they were allowed to decline or withdraw from the study with no consequences. Participants were also checked to refrain from obstacles such as any neurocognitive or physical incapacities. The investigators scheduled participation dates, and runners completed the trail route one time, running in small groups. For every part of the experiment, the participants were equipped with a mobile EMOTIV EEG headset, to monitor brain activity while running, and a Microsoft wristband, which recorded heart rate, HRV and climb rate.

The participants met in a public park in downtown Chattanooga with the investigators and once the participants were fitted with the equipment, they proceeded

with running the route. The route started in the park, passed onto a busy urban street that ascended in elevation for approximately 2.2 miles straight ahead. This portion of the route contains a multitude of buildings, vehicles, and traffic lights along the path. At the end of the street, they proceeded into a popular park called Stringers Ridge. Stringers Ridge has an abundance of looping trails that expose individuals to unimpeded natural environments. This rural portion of the race was approximately 2.2 miles and included multiple changes in altitude and scenery. Upon exiting the park, they descended down the same busy street as before, making their way back to the park. In total, the participants ran roughly 6.6 miles.

Once the data were collected from the participants, we analyzed the data to look for variations among environments. The brand of the EEG used, EMOTIV, has been used in numerous studies (Aspinall et al., 2015; Bailey, Johann, & Kang, 2017; Bailey, Demastus, Allen, & Herndon, 2018). These EMOTIV headsets have been substantiated to high-end research EEG systems (Badcock et al., 2015). These headsets contain five sensors that collect delta, theta, alpha, beta and gamma brainwaves through the frontal lobe, temporal lobes, parietal lobe. Low and high pass filters were put in place to remove any Delta frequencies (< 3 Hz0 and Gamma frequencies greater that 43 Hz. The filter was utilized by the hardware before altering the raw data into distinct wavelengths via Fast Fourier Transformation (FFT) (Bailey et al., 2018). These filters reduce undesirable articles in the data, produced by muscle movements and surrounding electrical signals in the atmosphere. The data was first screened for removal of noticeable artifacts, then transfigured into emotional states using established formulas from previous research. Focus (concentration) was measured as the presents of high frequency waves across the

frontal lobe (Coelli et al., 2015). Approach motivation (interest or enjoyment) was measured by frontal asymmetry (Coelli et al., 2015). Relaxation was measured as relative global alpha power across all sensors (Harmon-Jones, Gable, & Peterson, 2010).

We used a common EEG analysis approach to select consecutive blocks of time (called epochs) and measured variations between time points for each mental state (Wilson et al., 2015). For this study, we selected 2 built (uphill and downhill) and 2 natural environments (uphill and downhill) and also a flat portion found within the natural environment. We chose approximately 1-minute epochs of time in each environment (5 total) and each participant was given a score for each condition. This allowed for an overall comparison of the mental states over the duration of each condition for built and natural environments. All conditions were baseline adjusted by subtracting the baseline average from each condition (Hu et al., 2014). We conducted a 2x2 Analysis of Variance (ANOVA), with the 2 built conditions versus the 2 natural conditions as a between subject variable.

Results

We used a RM MANOVA to assess the differences in EEG-based cognitive states, with the built and natural environments as fixed variables. This allowed for insight into the changes of the five mental states across the continuation of each section, as well as for comparing time points across sections. The results showed there was a significant difference between the built and natural environments using different test, as shown in Table 1. Overall, there was a significant difference among cognitive states between built and natural environments, as seen in Table 2. There were significant differences associated across all mental states, except for the exception of a few points along the

running route, are shown in Table 3. Motivation was not significantly different at 5 different time points, arousal at two-time points and inward attention and relaxation at one time point each. The data points in Table 3 show that there are no motivational, arousal, inward attention or relaxation differences among those points given in the table.

Discussion

The purpose of this study was to gain a better understanding of the mental states of runners transitioning from an urban environment to a rural environment. The results of this study indicate that there are differences in mental states between urban and natural settings while accounting for the altitude of going up and downhill in both conditions. While this study was informational, it is important to take into account the limitations from this research. This study could have benefited from a greater sample size, also taking into account elevation effects of the natural and built environments. The route location presents another limitation for this study; smoother terrain that could be easier to maneuver through with more flat areas and possibly concrete or pavement paths would be another aspect to take into consideration.

However, this study showed a significant variation in focus between built and natural settings. This is confirmed by Berman and colleagues (2008) study that showed natural environments increase cognitive control. Differences in arousal state within this study is also reaffirmed by Pasanen, (2014) Mitchell, (2013) and Thompson Coon (2011) that showed lower anxiety levels within their studies. Results did show there was a significant difference ($p<0.01$) in focus between built and natural environments. We concluded that this phenomenon could have occurred because participants were having to concentrate on foot placement within the natural environment to avoid falls and injury.

There was a significant difference ($p<0.01$) between motivation going uphill in nature compared to the four other conditions, Figure 1. This is possible from the perspective that the participants were going uphill with unstable grounds to run on causes it to be more difficult to climb. There was a notable difference ($p<0.01$) in participants inward attention while going uphill in nature, Figure 2. This could be explained by individuals focusing on their breathing rate, heart rate, zoning out external environments and self-talk motivation to keep pursuing onward.

The product from this study have suggestions that athletes, leisure runners and other individuals interested in expediting health outcomes can benefit from. Performing activity in natural environments can come from many different activities, from running, hiking or group walks. A study from Hattie and colleagues (1997) showed outdoor related programs may induce mental and physical benefits. Another study by Godbey (2009) showed that individuals who visited local parks reported fewer visits to the doctor for chronic diseases. With previous studies and this study, it provides an option to deliberately interact with nature as a positive influence on a person's mental and physical well-being along with improvements in mental cognition.

Figures

Effect		Value	F	Hypothesis df	Error df	Sig.
Condition	Pillai's Trace	0.171	200.485	28.000	125960.000	0.000
	Wilks' Lambda	0.835	208.527	28.000	113529.415	0.000
	Hotelling's Trace	0.192	215.855	28.000	125942.000	0.000
	Roy's Largest Root	0.153	689.997c	7.000	31490.000	0.000

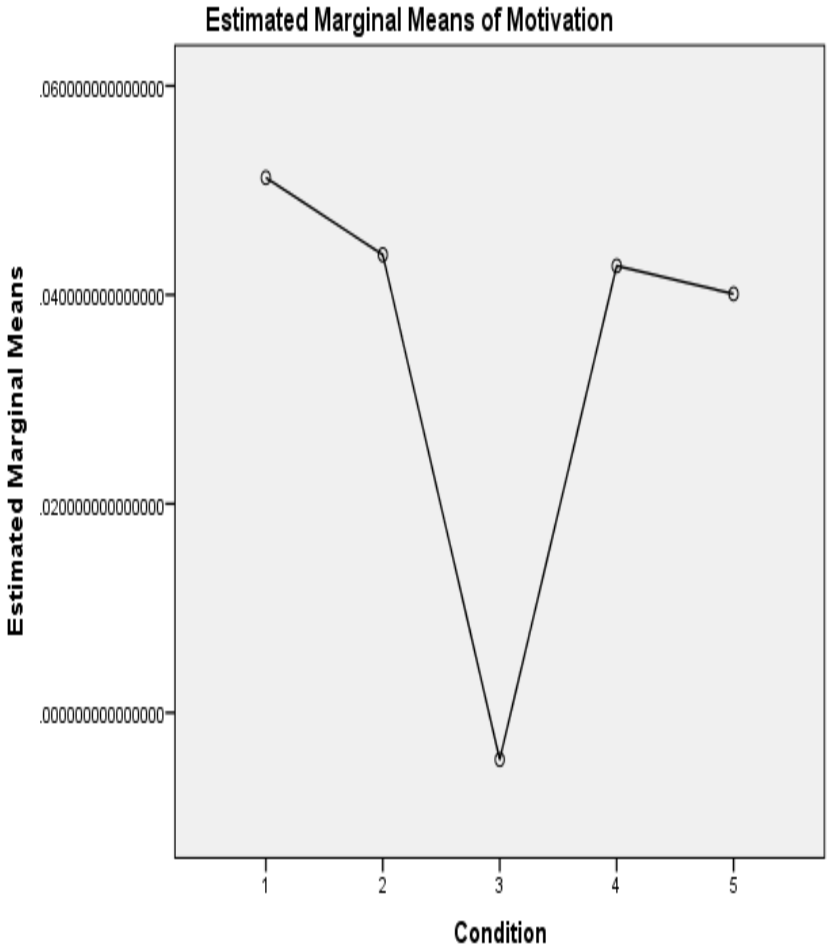
Table 1. Results of Built vs Natural Environments

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Condition	Focus	378.325	4	94.581	406.914	0.000
	Motivation	12.918	4	3.230	90.131	0.000
	Arousal	24.266	4	6.066	40.660	0.000
	Inward Attention	704348.524	4	176087.131	948.183	0.000
	HR_Interal	3.169	4	0.792	18.819	0.000
	Heart Rate	54128.495	4	13532.124	5.166	0.000
	Relax	7876688666716.800	4	1969172166679.20	160.068	0.000

Table 2. Mental states between Built vs. Natural Environments

Dependent Variable		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Motivation	1 vs 4	0.008	0.003	0.051	0.000	0.017
Motivation	2 vs 1	-0.007	0.003	0.215	-0.017	0.002
Motivation	2 vs 4	0.001	0.003	0.998	-0.008	0.010
Motivation	2 vs 5	0.004	0.004	0.822	-0.006	0.013
Motivation	4 vs 5	0.003	0.003	0.911	-0.006	0.011
Arousal	1 vs 3	0.001	0.003	0.995	-0.006	0.008
Arousal	4 vs 5	0.003	0.013	1.000	-0.032	0.037
IA	4 vs 5	-0.303	0.180	0.445	-0.794	0.189
Relax	5 vs 4	950.340	2789.791	0.997	-6661.985	8562.666

Table 3. Mental states of different time points. IA: Inward Attention, 1: Urban Uphill, 2: Urban Downhill, 3: Nature Uphill, 4: Nature Downhill, 5: Nature Flat


Estimated Marginal Means of Motivation
Estimated Marginal Means
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.020000000000000
.000000000000000
1
2
3
4
5
Condition

Figure 1.

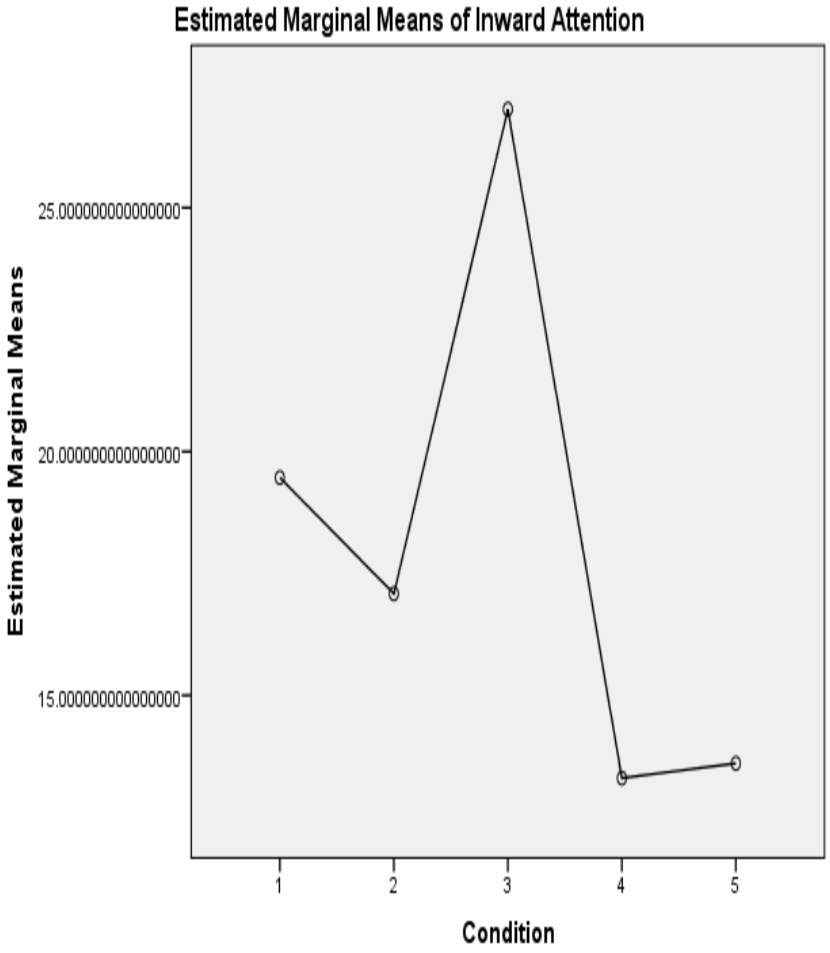
Estimated Marginal Means of Inward Attention
Estimated Marginal Means
25.000000000000000
20.000000000000000
15.000000000000000
1
2
3
4
5
Condition

Figure 2.

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