Cardiff Metropolitan University

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B.Sc. (Hons) Psychology

Final Year Project

**Effect of Environmental Stimulation on Stress Recovery**

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Dissertation submitted in partial fulfilment of the requirements of Cardiff Metropolitan University for the degree of Bachelor of Science
Declaration

DECLARATION

I hereby declare that this dissertation is the result of my own independent investigation under the supervision of my tutor. The various sources to which I am indebted are clearly indicated. This dissertation has not been accepted in substance for any other degree, and is not being submitted concurrently for any other degree.

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I would like to thank my supervisor for her excellent guidance and support throughout the project. I am so thankful for her constructive feedback which has helped me to improve my work, especially my writing style. At the beginning of the year I lacked confidence and doubted that I would be able to conduct this project but with her belief and fantastic support it has been made possible. I am grateful to have had the opportunity to explore this area of research and I have thoroughly enjoyed doing so.

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Abstract

Previous research has demonstrated that the urban environment can increase stress whereas the natural environment can aid stress restoration. Sounds of nature have been found to reduce stress in contrast to anthropogenic sound that can increase stress. The aim of this study was to explore the effect of natural and urban sounds on stress restoration, using birdsong and birdsong interrupted by traffic noise. A speeded arithmetic task was used to induce stress in participants. Electrodermal activity was recorded as a physiological measure of stress and a visual analogue scale was utilised to provide a self-report measure of stress. It was predicted that birdsong would cause greater stress restoration than birdsong interrupted by traffic noise. No significant interaction was found between the groups for electrodermal activity. A significant difference was found for self-reported stress; birdsong reduced stress significantly more than birdsong interrupted by traffic noise. The findings suggest disparity between physiological and self-report stress, future research should seek to address this.
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1.0 Introduction

There is a plethora of research which suggests that time spent engaging with the natural environment has a number of psychological benefits including but not limited to: promoting well-being, increasing cognitive functioning and reducing stress (Berman, Jonides & Kaplan, 2008; Hartig, Mang & Evans, 1991; Hansmann, Hug & Seeland 2007). However, 54% of the global population in developed countries reside within dense urban environments (United Nations, 2014). Therefore, engagement with nature is often experienced through urban green space which may not be providing the same psychological benefits as natural green space. Previous research in this area has given little consideration to the combined effect of natural and anthropogenic sounds on stress restoration. Urban green space such as city parks are often polluted with anthropogenic noise which may be negatively impacting upon the restoration that the sounds of nature can provide. Therefore, this study aims to explore whether the soundscape that is typical of an urban green environment provides the same restorative effect as a soundscape that is typical of a natural green environment.

1.1 Impact of Urbanised Living on Health

In 2014 over half of the global population resided in urban environments, this is in dramatic contrast to 1950 when over 70% of the global population resided in rural areas (United Nations, 2014). The rapid increase of urbanisation is highlighted by a recent United Nations report, which predicts that by 2050 the urban population will increase to 66% (United Nations, 2014). Urbanisation can provide a number of advantages such as innovation, wealth generation, enhancements in quality of living and economical usage of resources (Robinson & Swilling, 2012). However, there are many disadvantages such as increases in pollution levels, noise, stressors, overcrowding and reduced access to the natural environment which may be negatively impacting on both the physical and mental health of urban populations (Srivastava, 2009). There are many mental health problems that are associated with urbanisation, including severe mental disorders, depression, substance abuse, alcoholism, crime, family disintegration, and alienation (Srivastava, 2009). Depressive disorders are now the leading cause of disability in middle to high-income countries (The World Health Organization, 2008) and there is evidence which suggests that this may be associated with increasing urbanisation (Sundquist, Frank, & Sundquist, 2004). Reddy & Chandrashekhar (1998) conducted a meta-analysis which revealed higher rates of mental health problems in
urban areas than in rural areas, similar findings have emerged in more recent research. Lederbogen et al., (2011) utilised functional magnetic resonance imaging and found that the brains of urbanites differed from those living the countryside, in their handling of stress. Lederbogen et al., (2011) found that following the inducement of stress the amygdalae of urban participants showed greater activity than participants from the countryside, this is suggestive of heightened threat assessment and fear. Participants who had rural upbringings showed lower activity levels in the perigenual anterior cingulate cortex (pACC) compared to higher activity levels in urban upbringing participants. Patterns of activation between the amygdala’s and pACC in the urban participants were somewhat erratic, which is often seen in schizophrenia. Peen, Schoevers, Beekman & Dekker (2010) conducted a meta-analysis which revealed that the risk of schizophrenia is near to double for those who reside in a city, risk of anxiety disorders is increased by 21% and mood disorders are increased by 39%. These results suggest that it is of mounting importance that the impact of increasing urbanisation on health continues to be investigated.

In contrast to the negative effects that urban environments may cause, there is a vast amount of research which has shown that time spent in natural environments can have many positive effects. An example of the cognitive benefits is demonstrated in the findings of a field study conducted by Hartig et al., (1991). The study involved 25 participants embarking upon a wilderness vacation, 18 on a non-wilderness vacation and 25 remained at home, forming a control condition. Results found that attentional performance increased to the greatest degree for participants in the wilderness condition, this was also the case for self-reported happiness (Hartig et al., 1991). More recently Berman et al., (2012) investigated the effect of walking in nature on cognitive functioning, using a within subject design and a sample of 20 participants who had been diagnosed with major depressive disorder. After thinking about an unresolved negative life event that they had experienced participants then completed a 50-minute walk in either a natural or urban environment. Participants then completed a backwards digit span task which provided a measure of working memory. The Positive and Negative Affect Schedule (Watson et al., 1988) was used to provide an indication of mood. A significant increase in both working memory abilities and mood was found in participants following the nature walk relative to the urban walk. This study is perhaps somewhat flawed by its use of participants imagination and the within subject design. There may have been great variation in the negative value that participants placed upon the events which they recalled. The same participants repeated the study one week later in a different condition and recalled the same
event which they may have felt quite differently about having contemplated it previously. Although Berman et al.’s., (2012) study may have benefited from the utilisation of a more robust methodology, the results of the study and those aforementioned highlight the positive effects that the natural environment can produce.

1.2 The Effect of the Natural Environment on Stress Recovery

Studies have shown that exposure to the natural environment can aid perceived and physiological stress recovery (Thompson et al., 2012; Hansmann et al., 2007; Alvarsson, Wiens & Nilsson, 2010). Hansmann et al., (2007) assessed the restorative effects of spending time in urban green space. Participants completed surveys regarding levels of stress and balance before and after an urban nature engagement. Results found that reporting of headaches and stress levels significantly decreased and reporting of feeling balanced increased following the nature intervention. Results revealed that reported stress was 87% less and reports of feeling well-balanced increased by 40%. These results indicate that engagement with nature in urban green space can have significant positive effects. This study may have benefited from the addition of a control condition and the employment of a physiological measure as well as the self-report measure. Park, Tsunetsugu, Kasetani, Kagawa, and Miyazaki (2007) conducted a study exploring the physiological effects the Japanese art of Shinrin-yoku, which involves spending time taking in the forest atmosphere. The participants were split in to two groups which alternatively spent time walking around and observing in either a forest or a city area. Two physiological measures were utilised as indices of stress; cerebral activity in the prefrontal cortex and salivary cortisol levels. These were recorded before and after the interventions, the results found that both cerebral activity and salivary cortisol concentration were significantly lower for the group that spent time in the natural environment. Thompson et al., (2012) measured cortisol levels of participants residing in deprived areas in order to explore the relationships between stress, well-being and the effect of living close to green space. A significant relationship was found between self-reported stress, cortisol levels and the amount of green space close to home. A regression analysis further revealed that the amount of green space close by was a significant predictor of lower cortisol levels. Beil & Hanes (2013) also combined self-report and physiological measures of stress after exposing participants to four categories of virtual settings; very natural, mostly natural, mostly built and very built. Measurements of salivary cortisol and alpha-amylase were taken before and after participants were exposed to each setting. Participants also completed a 0-10 rating scale to provide a measure of their perceived levels
of stress. The results showed greater stress reduction in both physiological and self-reported stress following exposure to the natural settings compared to the built settings. The combination of both physiological and self-report measures is beneficial as insight is provided into both the physiological and psychological effects of natural and urban environments on stress recovery.

1.3 Theoretical Explanations for the Restorative Properties of the Natural Environment

Humans have an “innately emotional affiliation…to other living organisms” (Wilson, 1984), this statement depicts the essence of ‘Biophilia’. Wilson (1984) theorised that there is a cross cultural, innate human connection to nature that has evolved due to natural selection and begins in human DNA. There is an extensive body of research which suggests that engagement with the natural environment can reduce cognitive fatigue and improve cognitive functioning (Hartig et al., 1991; Berman et al., 2008). This research body supports Kaplan’s (1995) Attention Restoration Theory (ART) which suggests that the natural environment allows for the restoration of directed attention. The ART is based on the premise that there are two sections of attention (James, 1892; Buschman & Miller, 2007; Corbetta & Shulman, 2002). Voluntary/directed attention is required when a task is cognitively demanding such as studying or crossing the road. Whereas involuntary attention is an effortless process in which attention is captured by stimuli of soft fascination, such as a bird flying by in a natural environment. According to Kaplan’s (1995) ART, in order for restoration to occur there are four required factors; extent, being away, soft fascination and compatibility, all of which can be found in the natural environment. Soft fascination is deemed the key factor which results in the restoration of directed attention (Kaplan, 1995).

In contrast to the cognitive perspective of ART, Ulrich (1983) proposed the Stress Reduction Theory (SRT), which takes an emotional and physiological perspective on restoration. SRT proposes that physiological recovery is increased by exposure to the natural environment following the occurrence of stress. Ulrich et al., (1991) refers to Baum et al.’s., (1985) definition of stress; “the process by which an individual responds psychologically, physiologically, and often with behaviours, to a situation that challenges or threatens well-being”. The SRT has an evolutionary basis as it suggests that this restoration from the natural environment has evolved due to the threatening situations that humans encountered in their evolutionary past, which led to negative reactions (Joye & Van den Berg, 2011). According to SRT this restoration took place in natural environments with Savanna like qualities, which
provided safety and resources that were indicative of ample food supply and therefore reduced stress for this reason also (Ulrich, 1983). So, according to ART the restorative response induced by the natural environment is due to the replenishment of depleted cognitive resources whereas the SRT proposes that the restorative response is induced by unthreatening natural stimuli due to experiences in human’s evolutionary history. There are a range of perspectives which have been utilised to explain why natural environments may benefit stress recovery. The evolutionary perspective including biophilia, which acknowledges the role of living organisms. Stress recovery, which acknowledges the feeling of safety. The cognitive perspective which suggests that urban environments and modern living means we suffer attentional fatigue, whilst natural environments afford more involuntary attention.

1.4 The Effects of Natural Sounds on Stress

There is a vast amount of research which supports the notion that the natural environment can act as a buffer for stress and improve cognitive functioning (Thompson et al., 2012; Hansmann et al., 2007; Berman et al., 2012). This research has predominantly focussed on the visual experience of nature. However, increasing attention has been paid to other senses and particularly to sounds. Sounds of nature such as flowing water and birdsong have been found to promote restoration (Alvarsson et al., 2010), however this area of the research body is less well established. Annerstedt et al., (2013) measured physiological stress recovery following the inducement of stress through the utilisation of a virtual stress test. Saliva cortisol levels and cardiovascular data were recorded from participants who were exposed to a virtual natural environment that was accompanied with either sounds of nature or silence. Results found that participants in the sound condition experienced parasympathetic activation which is suggestive of enhanced recovery from stress. Whereas participants that recovered in virtual nature unaccompanied by sound and participants in the control condition did not display parasympathetic activation. These findings suggest that the audio element of nature experience can impact upon the stress reducing effect that the natural environment can provide. Hedblom, Heyman, Antonsson & Gunnarsson (2014) presented participants with urban images either alone or accompanied by birdsong. They found that positive ratings of the urban images increased when they were presented alongside the sound of birdsong, this association increased as the number of bird species heard in the audio track increased. Alvarsson et al., (2010) induced stress in participants using a speeded arithmetic task. Participants were then exposed to natural sounds, traffic noise or quiet. Two physiological
measures were utilised to measure stress; electrodermal activity and high frequency heart rate variability (HF HRV). A self-report measure was also employed in the form of a questionnaire regarding perceptions of the respective noises. The results showed that participants experienced a speedier recovery when exposed to natural sounds in comparison to traffic noise or quiet. Ratcliffe, Gatersleben & Sowden (2013) employed a self-report measure of restoration to investigate stress recovery. Participants were asked to recall a time that they were stressed, following this they were then asked to imagine an environment which would aid stress restoration. Natural sounds were frequently reported, of which 35% of them were birdsong. However, the use of participants imagination allows for variation in imagined stress therefore these findings could be made more robust with the use of a controlled stressor. Benfield, Taff, Newman & Smyth (2014) presented participants with a distressing video in order to induce negative mood. Following the video participants listened to natural sounds or a combination of natural and anthropogenic sounds. Results found that mood was improved for participants who listened to natural sounds only. These findings and those from the literature discussed, highlight the role that sounds of nature can have in increasing positive mood and reducing stress. This indicates that consideration should be given to the preservation of natural soundscapes, especially in urban green space which is susceptible to unnatural sounds. The findings from these studies suggest that bird song is the most influential of the natural sounds upon restoration and that the greater the biodiversity of the bird song that is heard, the greater the restorative effect.

In order to investigate the stress reducing effect of natural sounds these studies have all employed a stress inducing paradigm. This involves subjecting participants to a stressor, exposing them to the sounds and recording a measure of stress before and after. There are variations in the designs of these studies, Ratcliffe et al., (2013) asked participants to use their imagination to recall a stressful time which could potentially have great variation. Benfield et al., (2014) used a video of a hand being operated on, which may have been unpleasant viewing for some but not necessarily stressful. Benfield et al., (2014) used only a self-report measure; a 16-item Brief Mood Introspection Scale (Mayer & Gaschke, 1988). Alvarsson et al., (2010) induced stress in participants using a speeded arithmetic task before subjecting them to natural sounds. Dickerson & Kemeny (2004) conducted a meta-analysis reviewing 208 studies that had used psychological stressors, the results revealed that cognitive tasks such as mental arithmetic were amongst the most successful in inducing
stress. Whereas procedures that involved the presentation of emotion inducing material, such as a video were not associated with significant increases in stress.

1.5 The Effects of Anthropogenic Sounds on Stress

Sounds of nature may be promoting stress reduction although research suggests that anthropogenic noise is increasing stress (Hammer, Swinburn & Neitzel, 2014). Anthropogenic noise has been found to induce and exacerbate stress, disrupt sleep and decrease well-being (Babisch, 2003). Hammer et al., (2014) investigated the effects of anthropogenic noise on humans. Their results suggested that stress, poor sleep, heart disease and hearing problems are some of the negative effects of anthropogenic noise. Weinzimmer, Newman, Taff, Benfield, Lynch, and Bell (2014) presented participants with images of scenic views. Images that were presented with noises such as traffic and helicopters were perceived negatively in comparison to images presented with natural sounds. Pilcher, Newman and Manning (2008) conducted a similar study which explored the sound experiences of visitors to a National park. Following a listening exercise which took place in the park participants noted the sounds that they heard. They were then asked to rate how acceptable they found these sounds to be, which resulted in anthropogenic sounds being rated as annoying. Natural sounds were rated as pleasing in contrast to the man-made noises. This was a field study as opposed to the previously mentioned studies (Weinzimmer et al., 2014; Hammer et al., 2014) which were conducted in a lab environment. The findings are consistent despite the use of different methodologies. Nilsson & Berglund (2006) conducted a questionnaire study investigating attitudes towards soundscapes in suburban green areas that were dominated by natural sounds and city parks that were dominated by traffic noise. The results found that 84-100% of the respondents rated the natural sound of the suburban areas as good or very good whereas only 53-65% rated the soundscape of the city parks as good or very good. Nilsson & Berglund (2006) concluded that traffic noise needs to be below 50 dBA in order for the soundscape to be rated as good. This study demonstrates a human disliking of anthropogenic sounds and a preference for natural sounds. The general consensus from this area of research is that urban sound is disliked and has a negative impact on well-being in contrast to natural sounds which aid well-being and reduce stress. The negative effect of anthropogenic sound can potentially be explained by the ART (Kaplan, 1995), it may be that it requires directed attention which results in cognitive fatigue and in turn increases stress. Anthropogenic noise such as traffic noise or construction noise can be a signal of danger, which induces stress that can be restored by the natural environment, which is proposed by the SRT (Ulrich, 1983).
1.6 Rationale, Aims & Hypothesis

There is an extensive body of research which demonstrates that the natural environment promotes well-being and aids restoration. The majority of this research body has focussed on the visual aspect of engaging with the natural and urban environment (Thompson et al., 2012; Hansmann et al., 2007). Studies have explored the effect of natural and anthropogenic sounds on restoration, however these have been looked at separately. Previous research has found that natural sounds promote stress restoration (Alvarsson et al., 2010) and that anthropogenic noise increases stress (Hammer et al., 2014). This study aims to explore whether the same restoration is experienced when anthropogenic noise (traffic) and natural sound (birdsong) are combined. Fifty four percent of the global population reside in cities (United Nations, 2014), therefore engagement with nature is commonly experienced in urban green spaces such as parks. Parks in cities are often polluted with anthropogenic noise which may be impeding on the restoration that a natural soundscape should provide. The present study aims to investigate whether the same stress restoration occurs when anthropogenic noise and natural sounds are combined as it does when natural sounds are heard alone. This will be done by inducing stress in participants through the use of a speeded arithmetic task, similar to one that was successfully utilised by Alvarsson et al., (2010). Participants will then be exposed to birdsong, which has been found to be the most restorative of the sounds of nature (Hedblom et al., 2014), or birdsong interrupted with traffic noise which is often heard in urban green space. The physiological measure of Electrodermal activity will be used as a measure of stress, as this has been successful in previous research of a similar design (Jiang, Chang & Sullivan, 2014). A visual analogue scale will also be used to provide a second, self-report measure of stress. Based on the findings from previous literature it is expected that birdsong will reduce physiological and self-reported stress to a greater extent than birdsong interrupted with traffic noise.
2.0 Method

2.1 Ethical Considerations

Prior to the commencing of data collection ethical approval was sought and granted from the university ethics panel in December 2017. Prior to the conduction of data collection each participant was provided with an information sheet consisting of the study details and information regarding anonymity and confidentiality. The information sheet informed participants that the data would be anonymised and stored on a password protected computer. There were no potential risks to participants as they were to experience mild stress, no greater than that experienced in everyday student life. Participants were advised that after data collection had taken place data would be anonymised and therefore could not be later withdrawn.

2.2 Pilot Study

A pilot study was conducted in order for the researcher to ensure that the experiment ran smoothly. This also provided an opportunity for familiarisation with the materials and provided an estimation of running time. Following the pilot study participants provided feedback regarding the order of proceedings. Due to the electrodes needing a period of five minutes in order to ensure a good connection to the skin, doing this before going through the information sheet and explaining the study was deemed to be the best approach. Headphones needed to be put on prior to the electrodes being connected to the pads because this proved difficult otherwise. A pilot study participant suggested that the blinds were kept shut in order for the computer screen to be clearly seen, this also aided continuity.

2.3 Participants

A total of 27 participants were recruited to take part in the study, 9 in each condition. This sample size is in line with previous research of a similar design (Alvarsson, Wiens & Nilsson, 2010). The sample consist of undergraduate psychology students that were recruited using a South Wales University Department of Psychology Participant Panel. Participants received course credits in return for taking part in the study. There were 21 females and 6 males with an age range between 20 and 47 years of age (M = 23.7; SD = 5.63). The inclusion criteria required participants to be over 18 years of age.
2.4 Design

An independent experimental design was utilised for this study. There was one independent variable (IV) (type of natural stimulation) with three levels (silence, birdsong and birdsong interrupted with traffic noise). There were two dependent variables (DV’s); self-reported stress and physiological stress. Self-reported stress was measured using a visual-analogue scale of 1 -10 (1 represented very relaxed and 10 represented very stressed), this provided a measurement of participants perceived stress levels. This type of scale has been shown to be reliable in previous research (Nater et al., 2005). This scale was selected as the most appropriate scale to record stress as it provides a precise measure of acute stress unlike the commonly used Perceived Stress Scale (Cohen, 1994) which is designed to measure changes in stress over a period of time. Physiological stress was measured using electrodermal activity (EDA) which was recorded using a Biopac, this is in line with an approach used by Jiang et al., (2014). Both dependent variables were measured at three time points, pre-stress task, post stress task and post environmental stimulation.

2.5 Materials

Birdsong

A Rode NT1-A microphone was used to record birdsong in the middle of Bute park, Cardiff on 22/01/2018 at 7.30am. Birdsong was recorded at this time as it is a time of the morning when the park is populated with people engaging in activities such as a morning run, dog walking or walking to work. Therefore, it is a true representation of the level of birdsong that people hear in the mornings. The audio file was then processed using Audacity 2.2.2. The audio file was edited to four minutes in duration as this is in line with the time used by Alvarsson et al., (2010).

Birdsong Interrupted by Traffic Noise

The same Rode NT1-A microphone was used to record birdsong and traffic noise on the edge of Bute park, Cardiff. This was recorded at 8am during the morning rush hour. It was recorded at this time and place in order to give a true representation of the noise that is heard by people at this busy time of the morning. The audio file was then processed using Audacity 2.2.2. The audio file was edited to four minutes in duration as this is in line with the time used by Alvarsson et al., (2010).
**Speeded Arithmetic Stress Task**

Thirty equations and answers were created to be used for the stress inducing task. They consisted of addition, subtraction, division and multiplication using numbers between 2 and 999 (see appendix 4). Half the equations were presented with correct answers and half were presented with incorrect answers. They were presented for 3 seconds/3000 milliseconds. In the pilot study this was deemed a short amount of time to complete the task, which was stressful for participants. This was based on a similar task that was successful in inducing stress in participants when utilised by Alvarsson et al., (2010), to investigate stress recovery following exposure to environmental noise.

**The Experiment**

OpenSesame 3.1.9 was used to create the experiment. The stimulus sketch pad function was used to present instructions. The multiple-choice feedback function was used to present a sum, an answer and the options ‘true’ or ‘false’. The stimulus presentation time function was used to set the duration that each equation was presented for (3 seconds/3000 milliseconds). The response form function was used to present the participant with the correct response; either ‘true’ or ‘false’, following the presentation of the equation and answer. The noise sampler function was utilised to play the audio files for four minutes (240000 milliseconds). The audio files were set to be played at 60dB. The inline script function was used to set up triggers to the biopac at three times (Pre-stress task, post stress task and post stimulation), for 30 seconds each. This was created and presented to participants on a Viglen 64-bit computer.

**Recording Electrodermal Activity**

The Biopac system mp30 hardware with Biopac bsl4.0 software was used to record electrodermal activity. A Viglen genie computer running on windows 7 was used to run the Biopac software. EL507 electrodes were used to record electro-dermal activity between 0 – 35Hz. Following data collection Acqknowledge 4.4 was used to analyse the biopac data, which was run on another Viglen 64-bit computer. The data was recorded at 1000Hz, however it was transformed to 0.250Hz for analysis. The skin conductance reaction threshold was set to 0.01 which is in line with current standards (Braithwaite, Watson, Jones & Rowe, 2013). The mean number of event peak amplitude points were recorded for each of the 30 second trigger points.
Headphones

Beyerdynamic DT 231 headphones were used throughout the study.

Visual Analogue

A scale was created using Microsoft Word 16.11.1 to be used as a self-reported measure of stress. A 10cm line was replicated 3 times, at the top of the page, in the middle and at the bottom. Each line had 0 at one end and 10 at the other. Instructions were presented at the top of the document which explained that 0 represented very relaxed and 10 indicted very stressed (see appendix 3). This document was printed on white A4 paper.

2.6 Procedure

Set up, Instructions and Informed Consent

Participants completed the experiment individually in a controlled laboratory environment. Participants were greeted and given a verbal overview of the what the study would require of them. They were informed that electrodes would be placed on their left hand to record electrodermal activity. Electrodes were placed on the index finger and the middle finger, five minutes were then allowed to ensure that the electrodes had a strong connection with the skin. During this time participants were provided with the study information sheet containing further details of the study (see appendix 1). After this had been read they were then asked to sign a consent form (see appendix 2) if they were willing to take part in the study. Participants were then asked to wear the headphones. This was the case in all conditions including the control/silence condition, in order to block out any potential background noise. Wires were connected to the electrodes from the biopac. Participants were shown the VAS which was situated on the computer desk. They were informed that they would be instructed by the presentation to fill in the VAS at three time points. Participants were asked to place a horizontal line on the scale which represents how they felt at that time. Participants were told that they would use the mouse to select either ‘true’ or ‘false’ to a series of equations and answers. Participants were then informed that all of the instructions would be presented on the screen. Participants were then asked to take a deep breath to ensure the biopac was recording their EDA. They were then asked if they had any questions before the experiment would begin. The Biopac bsl4.0 software was then set to record and the OpenSesame experiment was activated (See appendix 5).
**Main Study**

Participants were instructed to provide a baseline measure of self-reported stress on the line 1/3 of the VAS. They were then asked to sit back, relax and remain still for 30 seconds whilst a baseline of their electrodermal activity was recorded. They were then instructed that the arithmetic task would begin when they pressed enter. Participants then had three seconds to select ‘true’ or ‘false’ to each of the 30 equations and answers. Following each equation, a slide with either ‘true’ or ‘false’ was presented to inform them of the correct response.

Participants were then instructed to provide a post-task measure of self-reported stress on line 2/3 of the VAS. They were again asked to sit back, relax and remain still whilst post-stress task electrodermal activity was recorded for 30 seconds. Participants then listened to either four minutes of birdsong, birdsong interrupted with traffic noise or silence. Participants were then instructed to provide a measure of self-reported stress on line 3/3 of the VAS. They were then asked to sit back, relax and remain still whilst post-stress task electrodermal activity was recorded for a final 30 seconds. This marked the end of the experiment, participants were informed of this on screen. Participants were left alone in the laboratory cubicle whilst the experiment was completed.

![Flow diagram showing the experiment running order](image)

*Figure 2.1 – Flow diagram showing the experiment running order*
2.7 Method of Analysis

Two 2x3 ANOVAS were used to analyse the data. This method of analysis was used because it is a mixed design that has one independent measures IV (with three levels) two repeated measures DV’s and ratio data which meets the assumptions of a parametric test. IBM SPSS 24.0 statistical program was used to conduct the analysis.
3.0 Results

3.1 Physiological Stress - Electrodermal Activity

Figure 3.1 shows the mean amplitude of skin conductance response for each condition at three time points; pre-stress task, post stress task and post stimulation. Mean amplitude was calculated by measuring the average peak value for each of the 27 participants. Figure 1 shows that the control condition (silence) experienced a greater increase in stress than the birdsong and birdsong interrupted with traffic conditions. The figure shows a very slight difference between the experimental conditions.

![Electrodermal Activity Pre-stress Task, Post Stress Task and Post Stimulation](image)

*Figure 3.1 Showing EDA mean peak amplitude for control, birdsong and birdsong interrupted with traffic noise at pre-stress task, post-stress task and post stimulation*

The two-way ANOVA revealed that there was a main effect of time (pre-stress task, post stress task and post environmental stimulation) on electrodermal activity. F(2, 48) = 8.049, MSE = 3.605, p = .001, η² = .251.

Pairwise comparisons showed that pre-stress task significantly differs from post-stress task p<0.05, however post-stress did not differ significantly from post-stimulation p>0.05.

There was no main effect of type of stimulation (birdsong, birdsong interrupted by traffic noise and control) on electrodermal activity. F(2, 24) = .101, MSE =7.847, p>0.05, η² = .008
No significant interaction was reported between effect of time and the three types of stimulation (birdsong, birdsong interrupted by traffic noise and control). F .034, 24 = 1.269, η 2 = .003, p > .05, F .192, 24 =12.076, η 2 = .016, p > .05, F .224, 24 = 15.861, η 2 = .018, p > .05.

The speeded arithmetic task led to significant increases in stress, as expected. However, no significant stress recovery was observed (using electrophysiological activity as a measure of stress) for any of the conditions (bird song, birdsong interrupted by traffic noise, control).

3.2 Self-reported Stress – Visual Analogue Scale

Figure 3.2 shows the mean self-reported stress levels for each condition at three time points; pre-stress task, post stress task and post simulation. Figure 3.2 shows that self-reported stress was similar for each condition at pre and post stress. The figure shows an increase in self-reported stress between pre-stress task and post-stress task for all groups. A decrease is shown between post-stress task and post stimulation. Self-reported stress for post stimulation was highest for birdsong with traffic noise, lower for the control (silence) and lowest for birdsong. A vast difference in self-reported stress post stimulation is shown between birdsong and birdsong interrupted with traffic noise. Post stimulation self-report stress is much lower for birdsong than birdsong interrupted with traffic noise.

![Self-reported Stress (VAS) Pre-stress Task, Post Stress Task and Post Stimulation](image)

*Figure 3.2 showing the mean for self-reported stress for control, birdsong and birdsong interrupted with traffic noise at pre-stress task, post-stress task and post stimulation*
Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, \( \chi^2(2) = 3.327, p > .05 \).

The two-way ANOVA revealed that there was a main effect of time (pre-stress task, post stress task and post environmental stimulation) on self-reported stress. F(2, 48) = 1.972, MSE = 5092.46 p = .001, \( \eta^2 = .641 \).

Pairwise comparisons showed that pre-stress task significantly differed from post-stress task for all conditions p<0.05. Post-stress task differed significantly from post-stimulation for birdsong and control conditions p<0.05, but not for birdsong interrupted with traffic noise p>0.05. So, there was a significant increase in self-reported stress between pre-stress task and post-stress task for all groups. A significant decrease in self-reported stress between post-stress and post stimulation was found for the birdsong and control conditions only.

There was no main effect of stimulation (birdsong, birdsong interrupted by traffic noise and control) on self-reported stress. F(584, 2) = .101, MSE =150.053, p>0.05, \( \eta^2 = .046 \)

A significant interaction was reported between effect of time and the three levels of group: Birdsong, F 19.595 = 2., \( \eta^2 = .630 \), p = .001, Birdsong interrupted with traffic F 14.11 =2, \( \eta^2 = .551 \), p = .001, and Control F 14.79 =2, \( \eta^2 = .563 \), p = .001.

The stress task led to significant increases in stress, as expected and there was a significant stress recovery observed (using the self-report scale as a measure of stress) for the birdsong and control conditions. No significant recovery was observed for birdsong interrupted with traffic noise.
4.0 Discussion

4.1 Study Overview

Previous research has supported Ulrich’s (1983) SRT by demonstrating that exposure to the natural environment can provide stress restoration (Berman et al., 2012; Thompson et al., 2012). However, much of the existing research has focused on the effects of the visual impact of nature (Beil & Hanes, 2013; Hansmann et al., 2007), with less attention being paid to the effect of sounds from the natural environment. Alvarsson et al., (2010) compared the effects of anthropogenic sound (traffic) and natural sound (birdsong and running water) heard independently, on stress restoration. Findings suggested that birdsong caused greater restoration. Due to rapidly increasing urbanisation the majority of the population engage with nature through urban green spaces of which the soundscape is often natural sounds polluted with anthropogenic noise. The present study aimed to explore the effects of natural sound (birdsong) in comparison to natural sound combined with anthropogenic noise (birdsong and traffic noise) on stress restoration, following induced stress via a speeded arithmetic task. It was hypothesised that greater physiological and self-reported stress restoration would be demonstrated after participants had listened to birdsong in comparison to listening to birdsong interrupted with traffic noise.

4.2 Findings

4.21 EDA findings

It was hypothesised that electrodermal activity, the physiological measure of stress, would be significantly reduced after participants had listened to birdsong but not after they had listened to birdsong interrupted with traffic noise. However, there was no significant physiological stress recovery observed for birdsong, birdsong interrupted with traffic noise or the control condition. A perplexing trend in this data is seen in the control condition in which participants displayed higher levels of EDA than participants in either of the stimulation conditions, following the recovery period. There are a number of possible explanations for this trend in the data. It is conceivable that during the four-minute period without stimulation participants were involved in thought that increased their stress levels. The sample consisted of students and the study was conducted towards the end of the academic year when assignments and exams are looming. Therefore, it is plausible that this particular sample may have been more inclined to enter into stress inducing thought than a sample that did not consist solely of a student population. With regards to lack of stress reduction in the birdsong condition, this again may
be due a number of factors. It is possible that the birdsong did not consist of great enough biodiversity, as it has been suggested in previous research (Hedblom et al., 2014) that the greater the number of species that is heard, the higher the restoration has been rated. Another possible explanation for the lack of effect is that participants may have been worrying that they would be required to complete another stress task. Also, due to the stress task being a speeded arithmetic task which was designed to be slightly too difficult and too fast to complete successfully, it was expected that participant would struggle to do well and therefore be stressed. However, participants were unaware that their answers were not being recorded, which may have resulted in them worrying about how badly their scores would be during the stimulation period.

4.23 Self-report Findings

It was hypothesised that listening to birdsong would also result in a reduction of self-reported stress to a greater extent than listening to birdsong interrupted by traffic noise. This hypothesis was supported as there was a significant reduction in self-reported stress found in the birdsong condition whereas no significant reduction was found for birdsong interrupted with traffic noise. These findings are as predicted and are in line with previous research which has found that natural sounds aid stress restoration (Alvarsson et al., 2010; Ratcliffe et al., 2013). Ratcliffe et al., (2013) also utilised a self-report measure of stress restoration to investigate the effect of birdsong on stress recovery, however their methodology differed considerably to that of the present study. Participants were required to recall a time that they were stressed and to imagine an environment that would reduce stress. The use of participants' imaginations to induce stress is perhaps a dubious method which lacks control. However natural sounds were commonly reported as the imagined stress reducer, 35% of which were birdsong. The present study benefited from the utilisation of a controlled stressor and the results infer the same conclusion; birdsong is perceived to reduce stress. These findings are given greater support when considered alongside those of Alvarsson et al., (2010) whose findings also suggest that following the induction of stress, significantly greater recovery results from exposure to natural sounds in comparison to anthropogenic noise. The results of this study show that self-report stress was reduced only slightly between post-stress task and post birdsong interrupted with traffic noise. This finding is also in line with previous research (Babisch, 2003; Hammer et al., 2014) which has found anthropogenic noise to aid stress. Although there was a small reduction in stress displayed in this condition, it is possible that
this was due to the presence of birdsong of which may have provided some stress restoration. The control condition also decreased in self-reported stress to a greater extent than the traffic interrupted with birdsong, but not to the same extent as birdsong. Therefore, it seems that on a level of self-perceived stress, natural sound such as birdsong is restorative but when it is interrupted with anthropogenic sound (traffic noise), the perceived restorative effect is largely reduced.

There is disparity between the physiological stress and self-report stress findings. Birdsong reduced self-reported stress significantly and traffic noise and birdsong did not. However, these findings are in contrast to those from the EDA, which was not reduced significantly by birdsong. A number of possible explanations have already been discussed in regard to the unexpected EDA findings. For example, the fact that participants may have been anticipating another stress task or worrying about their poor performance. The same principles could be said of the self-report measure, although participants could have been consciously aware that they could or should feel less stress after listening to the birdsong. Therefore, participants may have reported how they thought they should feel rather than how they actually felt. It may be that they were concerned about their scores and the possibility of a further arithmetic task and if this was not the case they would have may have demonstrated a reduction in physiological stress after listening to birdsong. If this was the case, it may be that they reported how they thought they would feel if they not had these concerns.

4.3 Implications of Findings

The stress reducing effect of natural sounds and of birdsong in particular has been well documented (Alvarsson et al., 2010; Ratcliffe et al., 2013). As has the stress inducing and maintaining effect of anthropogenic noise and traffic noise especially (Taff et al., 2014, Hammer et al., 2014). The present study sought to explore whether the same restoration is provided when natural and anthropogenic sounds are heard in combination, as they often are in urban green space. The findings suggest that at least on the level of self-reported stress, anthropogenic noise significantly impedes upon the restorative effects of birdsong. As was discussed in chapter 1.1, over half of the global population currently reside in urban environments, therefore access to natural green space is decreasing (United Nations, 2014). Although there are advantages to increasing urbanisation there are also many disadvantages such as the negative impact on mental health and increased stress (Srivastava, 2009), which can be mediated by engagement with nature (Berman et al., 2012). However, access to the
natural environment is becoming more and more limited. The findings of the present study suggest that the soundscapes of urban green space may not be providing the restoration that they could be due to the negative impact of anthropogenic noise. This should be considered by urban designers when future urban development takes place. For example, they should seek to make large urban green spaces which allow for people to get far enough away from the traffic noise so that it cannot be heard. Councils may also seek to increase biodiversity in urban green parks as this has shown to increase the restorative effects (Hedblom et al., 2014) and may act as a mask to the anthropogenic noise. Councils should put cycle and walk to work schemes in place and increase cycle paths throughout cities, encouraging people to reduce car use. If public transport were to be subsidised by the government, this would potentially reduce the number of cars on the road. Further policies could be put in place to encourage the use of electric cars which not only reduce toxic omissions but reduce anthropogenic noise pollution also. All of these suggestions could reduce traffic noise and therefore result in a far more pleasant and stress reducing soundscape, particularly in urban green spaces.

4.4 Limitations and Future Research

It is possible that participants were not aware that they would not be completing a further speeded arithmetic task. The EDA reading may well have been impacted upon by this. It would be beneficial to conduct a similar study that controls for this possibility, by ensuring participants are aware that they will complete only one stress task. Although previous research in this area has used EDA to measure physiological stress (Alvarsson et al., 2010; Jiang et al., 2014) recent studies which have investigated stress and the natural environment have employed other physiological measures such as saliva cortisol levels and cardiovascular data (Annerstedt et al., 2013). Future research could explore the effects of natural and anthropogenic sounds on stress restoration to a greater extent than the present study, through the combined employment of multiple physiological measures.

As discussed previously, the use of a student sample at a stressful time of the academic year may have had an impact on the findings of the current study. Therefore, future research of this nature should seek to recruit a diverse sample to avoid this possibility. Another potential issue with the sample of the current study is that it consisted of a student population who have resided in an urban environment for at least the duration of their studies. Therefore it is likely that traffic noise and birdsong was familiar to them, as it is heard in the city parks in
Cardiff, future research may seek to control for this. For example, this study could be conducted twice with two groups; city residents and country residents. To explore whether there are differences in the impact of the stimulation between the two groups. As previous research has suggested that the brains of urbanites differed from those living the countryside, in their handling of stress (Lederbogen et al., 2011). Another avenue that could be explored is the impact of upbringing, for example current city dwellers could be recruited and split in to two groups: those who grew up in the countryside and those who grew up in an urban environment.

This study may have benefited from the addition of another condition, in which participants were exposed to traffic noise alone. This would have allowed for further comparisons to be made, providing greater insight in to the effect of anthropogenic noise, natural sounds and anthropogenic and natural sounds combined. Future research may seek to build upon the findings of the present study by addressing the discussed limitations of this study. The use of a speeded arithmetic task was successful in inducing stress in participants and it has been shown to be previously (Alvarsson et al., 2010), therefore this is a material worthy of utilisation in future studies. The addition of a traffic noise condition, multiple physiological measures of stress and experimentation with different samples are some of the factors that could be addressed in order to add to the existing findings of this study and the wider research body.

4.5 Conclusions

This study aimed to address a gap in the literature, by exploring the impact of anthropogenic and natural sounds heard in combination, on physiological and self-reported stress restoration. Disparities were found between the measures as physiological stress which was measured using EDA was not reduced by birdsong. In contrast to this and as predicted, self-reported stress was significantly reduced by listening to birdsong but not by listening to birdsong interrupted with traffic noise. However, potential methodological flaws and sample issues may explain the disparity. The findings from self-reported stress support previous research which has found birdsong to provide stress restoration (Alvarsson et al., 2010; Ratcliffe et al., 2013) and anthropogenic noise to impede upon stress restoration (Hammer et al., 2014; Babisch, 2003). As urbanisation continues to increase rapidly and in line with a rise in mental health problems, it is important that the disruption of natural soundscapes by anthropogenic noise and the effect this has on humans continues to be investigated.
5.0 References


6.0 Appendices

6.1 Appendix 1: Information Sheet

Title of Project: Effect of Environmental Stimulation on Stress Recovery

Participant information sheet

The study

There is a vast amount of research which has found that engagement with the natural environment has numerous benefits to health and wellbeing. However, the population is growing and the majority of people are living in urban areas therefore their access to the natural environment is mostly through the use of urban green spaces such as city parks which are polluted with urban noise. This study will be focussing on the role of sound in urban nature experiences, by exploring the effect that the intertwining of natural and urban sounds has upon stress restoration.

What would happen if you agree to participate?

The data collection will take no more than half an hour. You will complete the task alone in a lab, using a computer. You will complete a cognitive task, listen to an audio track and complete a short questionnaire. You will be attached to a Biopac which will measure galvanic skin response (GSR) which is a measure of stress.

Exclusion criteria

This study requires that participants are over 18 years of age.

Potential Risk

There are not expected to be any at major risks. Discomfort may be caused by the inducement of mild stress; however this stress will be no greater than experienced in everyday student life.

Potential benefits

By participating you could be contributing to research that may help to improve the way green spaces are created and maintained in urban areas, which will beneficial for many people.

Withdrawal, anonymity and confidentiality
If you do not wish to proceed with your participation in the project you have the right to withdraw at any point, please let me know using the contact details that are provided below. If you decided that you wish to withdraw during the data collection session you are welcome to inform me in person. However, once data collection has taken place it will not be possible to remove your data from the project as it will be unidentifiable.

You will not be required to provide any personal information on the questionnaire that you will complete, this will ensure that the information you provide is completely anonymous. Each time a data collection session takes place, the data will be transferred in to excel, stored on a password protected PC to which only myself and my supervisor will have access to.

If you have any questions about the study, please contact the project supervisor:
PARTICIPANT CONSENT FORM

Reference Number: 9743
Participant name or Study ID Number:
Title of Project: Effect of Environmental Stimulation on Stress Recovery
Name of Researcher:

___________________________________________________________________

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time before leaving the experiment, without giving any reason.

3. I agree to take part in the above study.

_______________________________________   ___________________
Signature of Participant                  Date

_______________________________________  ___________________
Name of person taking consent            Date

_______________________________________
Signature of person taking consent

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6.3 Appendix 3: Visual Analogue Scale

When instructed to do so please indicate by marking on the lines below how you feel at that time.
0 represents very relaxed and 10 indicates very stressed.

1) 

0 10

2) 

0 10

3) 

0 10
6.4 Appendix 4 – List of Equations, Answers and Correct Responses

1. \( 365 + 152 = 517 \)  Correct response: True
2. \( 543 - 345 = 198 \)  Correct response: True
3. \( 277 \times 3 = 864 \)  Correct response: False
4. \( 711 \div 9 = 79 \)  Correct response: True
5. \( 493 \div 294 = 786 \)  Correct response: False
6. \( 282 - 138 = 146 \)  Correct response: False
7. \( 913 \div 83 = 11 \)  Correct response: True
8. \( 8 \times 72 = 574 \)  Correct response: False
9. \( 821 \div 386 = 435 \)  Correct response: True
10. \( 799 - 247 = 531 \)  Correct response: False
11. \( 833 + 119 = 952 \)  Correct response: True
12. \( 688 \div 43 = 19 \)  Correct response: False
13. \( 17 \times 13 = 221 \)  Correct response: True
14. \( 966 \div 23 = 42 \)  Correct response: True
15. \( 539 - 376 = 164 \)  Correct response: False
16. \( 435 + 319 = 773 \)  Correct response: False
17. \( 179 \times 4 = 716 \)  Correct response: True
18. \( 336 \div 6 = 56 \)  Correct response: True
19. \( 733 - 397 = 377 \)  Correct response: False
20. \( 984 - 488 = 496 \)  Correct response: True
6.5 Appendix 4: Slides from OpenSesame Experiment

Please fill in the Visual Analogue Scale on the piece of paper in front of you. On the line marked 1) please indicate how stressed you currently feel.

Press enter once you have done this.

You will be presented with a series of sums and answers. You will have 3 seconds to decide if you think the answer is true or false.

Please use the mouse to select either ‘true’ or ‘false’.

There will be a short delay before the sums begin, please wait patiently.

Press enter when you are ready to begin.

Please ensure you are wearing the headphones.
Please fill in the Visual Analogue Scale on the piece of paper in front of you.

On the line marked 2) please indicate how stressed you currently feel.

Press enter once you have done this.

Please sit still and wait for the next slide.

You will now listen to an audio track for four minutes.

Please fill in the Visual Analogue Scale on the piece of paper in front of you.

On the line marked 3) please indicate how stressed you currently feel.

Press enter once you have done this.

End of study.
Thank you for your time!
# 7.0 Word Count

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Signed:

Date: 19.04.18