

Nature soundscapes in apps and workplace design for the millennial generation: mood and arousal, stimulation, and distraction.

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ABSTRACT

The millennial generation's media multitasking behaviour may negatively impact their ability to ignore distractions and sustain attention. Background nature soundscapes may be used to block out distracting sounds or to create a stimulating environment whilst working or studying. Previous research into the effects of listening to music has shown that it can improve performance in certain tasks because it lifts mood and is cognitively arousing. However, background sounds can cause distractions that negatively impact performance in some tasks. This includes tasks that require some degree of serial recall. The current research employed both an experiment and a diary study to investigate the potential impact of the use of nature soundscapes by millennial generation students. In the experimental study, it was found that nature soundscapes did not increase positive mood or cognitive arousal. When compared to a soundscape with low acoustic variation, a nature soundscape with high acoustic variation negatively impacted performance in a mental arithmetic task that requires serialization in working memory. No difference in performance was found when these soundscapes were compared to silence. The diary study revealed that nature soundscapes were viewed as a tool for stabilizing mood, masking external distracting sounds, and providing a background ambience conducive to study.

Author Keywords

Media multitasking; millennial generation; soundscapes.

ACM Classification Keywords

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1. INTRODUCTION

Media multitasking is the act of engaging with discrete tasks or multiple streams of media from two or more mediums, typically electronic devices. More young people media multitask than older generations [7]. A high proportion of these media multitaskers listen to music or the radio whilst performing other tasks such as working or studying [7]. Some may listen to non-music sounds such as nature soundscapes with the aim of lifting mood or to mask intruding environmental noise. There is a proliferation of mobile applications that provide these nature soundscapes for work and study. However, it is not only individuals with personal devices who are using nature soundscapes in this way. The designers of office environments have begun to consider the utility of using naturalistic soundscapes both as a more stimulating alternative to traditional masking sounds such as white noise [8], and because they may have restorative effects [32]. However, the evidence for the benefits of nature soundscapes is limited and the effects of distracting auditory stimuli may be a particular issue for the millennial generation.

Heavy media multitasking is associated with an inability to ignore distracting stimuli [25] and reduced ability to sustain attention [46]. However, auditory stimulation may help with some cognitive processes in some circumstances. Previous research into the effects of listening to music may provide some insight into these benefits. Listening to a short piece of music before task performance has been shown to increase cognitive arousal and positive mood [36]. These benefits are associated with increased performance in a subsequent task that requires working memory [34, 35, 36]. The benefits of auditory stimulation have also been found in young people with attentional deficits who completed tasks in an environment with background white noise [39]. However, some background soundscapes may lead to interference from irrelevant sounds [28]. Specifically, this interference impacts tasks that involve some degree of serialisation in working memory, such as mental arithmetic [3] or reading [18].

Listening to nature soundscapes has been found to benefit restoration following a cognitively demanding task [14]. However, the impact of listening to nature soundscapes whilst also being engaged with a task has received little attention. It is not known if nature soundscapes increase

mood and arousal in the same way that listening to music does. Research that shows exposure to nature lifts mood [11] and impacts other types of cognitive processing [47] suggests that this may be the case. However, it is not known if any cognitive benefits from listening to nature soundscapes will be sufficient to impact performance in a cognitively demanding task. Finally, it is not known if high acoustic variation in a nature soundscape will have the same detrimental effects on serialisation in working memory as it has been found to have in music [28] and office noises [3]. Therefore, the current research aimed to investigate the effects of nature soundscapes and their potential use in the context of the millennial generation at work or study.

This research was composed of one experimental study and one diary study. The experimental study attempted to identify if mood and arousal were affected by nature soundscapes in the same way that they are affected by music [36]. If this were the case, there may have been a subsequent increase in performance in a task that requires working memory. However, as no effect was found it can be concluded that nature soundscapes do not have these beneficial effects. The experimental study also investigated if high acoustic variation in the nature soundscape would negatively impact task performance. A negative impact was found when high acoustic variation was compared to low acoustic variation, but not when compared to a control condition of silence. The diary study sought to investigate how millennial generation students reported their experience of studying whilst listening to nature soundscapes, including their affective state and the contextual factors that impacted the use of soundscape apps. It was found that nature soundscapes were used to establish personal space and an environment conducive to studying. However, individual differences relating to past experiences and the individual's need for stimulation may be a factor that determines when these soundscapes are appropriate and how useful they may be. In addition, it was found that participants selected sounds that had infrequent or predictable segmented sounds. In this way participants selected low acoustic variation sounds and reduced the potential for distraction.

2. RELATED WORK

In order to understand the impact of nature soundscapes in the millennial generation's study environment, it will be necessary to draw on research from four different areas. First, the differences in attention and cognitive processing that may result from habitual media multitasking behaviours need to be considered because this may be a characteristic of the millennial generation that impacts their sensitivity to auditory distraction. Second, the specific behaviour of listening to background nature soundscapes whilst working may be based on unqualified claims that this act benefits productivity. These claims are based upon the 'biophilia hypothesis' that suggests humans benefit psychologically from exposure to nature. Therefore, a

consideration of this hypothesis and why it is being introduced into workplace design will be reviewed. Third, given the limited research into the effects of nature soundscapes it is necessary to draw from literature that focuses on the benefits of listening to other forms of auditory stimuli. Finally, studies in this area have focussed on the effects of auditory stimuli listened to before task performance. Therefore, the fourth area of review shall be on studies that focus on the effects of background auditory stimuli during task performance.

The millennial generation and media multitasking

Born after 1979, the millennial generation engages in substantially more media multitasking behaviours than older generations [7]. However, multitasking behaviour may negatively impact cognitive abilities. A review [46] of studies into the effects of media multitasking on young people found that media multitasking was associated with reduced performance in tasks of cognitive control, socio-emotional functioning, and academic performance. The underlying cause of this negative impact on cognitive abilities could be changes in attentional processing.

It is argued that having grown up with multiple devices, young people have a cognitive adaptation to frequent task switching behaviour [48]. Heavy media multitaskers are less able to filter out distracting stimuli than light media multitaskers [25]. According to the 'scattered attention hypothesis' [46], frequently attending to multiple media leads to a 'breadth-bias' in cognitive processing that results in increased sensitivity to distracting stimuli. Consequently, media multitasking may lead to a decrease in cognitive control abilities and a deficit in the ability to sustain attention.

Certain behaviours that are intended to increase concentration may have a further negative impact on attention and cognitive control. Young people have reported that they are most frequently engaged in multitasking behaviour at home when they are listening to music whilst performing other tasks such as surfing the web or sending emails [7]. In addition, anecdotal reports suggest that students listen to music [45] or to nature soundscapes whilst studying [31]. This may be to block out distracting sounds or to produce a pleasant ambience. Further analysis reveals the popularity of these nature soundscapes. The website rainymood.com which plays a rain soundscape received 2.9 million hits in the month of writing (May 2016) [38]. Furthermore, at the time of writing, searching for 'nature sounds' in the Google Play Store returned over 150 different apps for playing nature soundscapes.

Media reports have claimed that listening to natural soundscapes such as birdsong can increase productivity at work [50]. This is an important claim to investigate, because if integrating nature soundscapes into work and study environments increases concentration, this type of intervention may particularly benefit heavy media multitasking millennials. A trend towards incorporating

natural elements in workplace design means that ergonomists have already begun to consider what these effects may be.

Biophilia in workplace design

Poor indoor environmental quality impacts work performance by reducing motivation and increasing the likelihood of cognitive fatigue and distraction [19]. Previous research has tended to focus on the affects of environmental stressors on productivity, including lighting, temperature and ambient noise conditions. However, Olson [24] argues that the design of workplaces should not only protect against factors that impact productivity but also attempt to increase productivity through a focus on wellbeing. One wellbeing-centred approach to workplace design that has become popular in recent years is the use of nature in design, and the introduction of naturalistic elements in to the working environment. Richardson and colleagues [32] argue that workplace wellbeing is a fundamental concern of ergonomics. Therefore, as exposure to natural elements can improve wellbeing, it follows that 'nature should be a new paradigm for ergonomics' [32]. The 14 Patterns of Biophilic Design [14], and four elements approach proposed by Fitzgerald and Danner [9] provide frameworks for the integration of natural elements into workplace design. The justification of these approaches is rooted in applied evolutionary psychology and the 'biophilia hypothesis' [49].

The biophilia hypothesis proposes that human beings have an innate drive to connect with nature and living systems. It is argued that this drive is the product of biocultural evolution that occurred in an environment in which we depended upon our knowledge and relationship with other living systems [49]. Subsequently, offspring that had a propensity for appropriate behavioural responses to those living systems had an evolutionary advantage. Studies have shown a cross-cultural preference for natural landscapes over built environment landscapes (see [44], for a discussion). This effect is particularly strong for natural landscapes that appear to have utility for survival [17]. These findings are congruent with the biophilia hypothesis. However, as Kahn [16] points out, the extent to which biophilia can be attributed to genetics is questionable because it is very difficult, if not futile, to experimentally separate inherited and learnt psychological characteristics. As such, the biophilia hypothesis lacks falsifiability. Nevertheless, exposure to naturalistic stimuli has consistently been shown to have beneficial effects on psychological health and measures of nature relatedness have been found to be a distinct predictor of happiness [51]. The impact on young workers in the millennial generation is of particular concern as the integration of naturalistic elements in design becomes more popular.

Auditory naturalistic stimuli have been found to have restorative qualities. Alvarsson et al. [1] investigated the effects of natural sounds on recovery from psychological

stress and argue that participants recovered quicker when exposed to nature sounds than ambient building noise or road traffic sounds because they found them more pleasurable. Jahncke et al. [14] compared the psychological and physiological effects of working in a high-noise open office space and a low-noise open office space. Recovery from these environments was then compared across four conditions in a 7-minute restoration session, including a natural sounds condition. Exposure to river sounds led to higher self-reports of motivation than office sounds. However, whilst these studies have demonstrated that nature soundscapes may be beneficial for restoration periods after cognitive exertion, it is not known if they may confer benefits if they are listened to before or during task performance. Most of the research that has considered the impact of auditory stimuli before task performance has focused on the effects of listening to music.

The arousal and mood hypothesis

It is important to consider research into the beneficial effects of listening to music because the mechanism that creates these benefits may also be activated by nature soundscapes. The 'Mozart effect' describes the finding that listening to Mozart for a short period increases performance in a spatial manipulation task completed afterwards [29]. Attempts to replicate these findings with other types of music have led to the identification of a 'Schubert effect' [23] and a 'Blur effect' [35]. Furthermore, these benefits have been found in other tasks such as IQ subtests and creativity [36].

Variations in the effect size that results from listening to different types of music have been used to explain why music may confer benefits in cognitive processing. Nantais and Schellenberg [23] found that for children, listening to Blur was more beneficial than listening to Mozart. This finding suggests that differences in effect size are associated with the children having a musical preference for Blur.

Listening to a preferred piece of music may benefit cognition because this act increases both positive mood and levels of cognitive arousal. This has been termed the 'arousal and mood hypothesis' [34]. However, further research has found that whilst both arousal and mood may confer benefits, these benefits depend more on arousal than mood [36]. Furthermore, levels of arousal and mood may also be susceptible to tonal and temporal aspects of the music. Husain et al. [13] took a single recording of a Mozart sonata and varied it in terms of tempo and mode. Performance in a subsequent spatial ability task was better when the music listened to was at a faster tempo and in a major mode. In addition, tempo was found to be related to arousal and mode related to mood. If tonal and temporal aspects are fundamental causes of these effects the extent to which these findings can be generalised to nature soundscapes is questionable because these two qualities are not present.

Despite most research focussing on the effects of arousal and mood in the context of music listening, it has been argued that the arousal and mood hypothesis is not specific to music [36]. In support of this claim, these benefits to cognitive processes have been found with non-musical auditory stimuli, such as listening to a narration of a Stephen King Story [23]. As increased mood is associated with nature exposure [11], nature soundscapes may increase mood and arousal in a way that benefits subsequent task performance. However, studies that provide evidence for the benefits of listening to auditory stimuli [23, 13, 35, 36] consider its effects in terms of *sequentially* listening to a stimulus and then performing a task rather than *concurrently* listening and performing a task. Therefore, this may not reflect the way the millennial generation uses music or nature soundscapes.

The irrelevant sound effect

Perham and Vizard [28] argue that studies measuring task performance after listening to music (e.g. [36]) are unrealistic because they do not reflect how young people actually use background auditory stimuli whilst concurrently performing a task. In this way, the auditory stimuli could be understood as having moved from the foreground to the background of attention. The consequences of this for young people may be particularly important given the literature that suggests their heavy media-multitasking behaviour has created a breadth-bias in attentional processing [46]. These individuals may be more susceptible to auditory distractions in the background noise.

The 'irrelevant sound effect' (ISE) describes the sudden inability to ignore distracting sounds in the environment and is produced by the presence of salient acoustic variations in background noise. For the ISE to occur, the task being performed needs to require cognitive processes vulnerable to its effects. These are tasks that have some need for serialization in working memory [4], such as mental arithmetic tasks [3] and reading [18]. Perham and Vizard [28] found that the ISE was present regardless of whether or not the participant had a preference for the music that they were listening to. Therefore, whilst listening to background music may increase cognitive arousal, these benefits do not overcome the effects of interference from distractions. Variations in the degree to which the ISE may occur have been explained by an examination of acoustic variation in the background noise.

The ISE has been explained with the changing-state hypothesis [15]. According to this hypothesis, auditory distractors that include a high amount of acoustic variation interfere with the serial recall of information in short-term memory (STM). This acoustic variation must include some form of segmentation in the background auditory stimuli, so that sounds are discrete and not continuous. It is argued that the changing-state effect occurs because even non-relevant distracting sounds are automatically processed by perceptual mechanisms. Therefore, salient auditory

distractors may interfere with subvocal rehearsal in STM because of an unavoidable capture of attention [20].

An unavoidable capture of attention interferes with task performance because cognitive capacity is a limited resource [2]. As such, a distinct auditory stimulus in a background soundscape may be pre-attentively processed. This processing will necessarily reduce the resources available for the primary task. The extent to which interference may occur depends upon individual differences in attention and the complexity of the task being performed, with tasks requiring sustained attention and recall being most affected [10]. Banbury and Berry [3] investigated the effects of changing-state sounds in a novel mental arithmetic task that requires serial recall and found that they decreased task performance. Banbury and Berry used various office noises such as keyboard taps to simulate acoustic variation. To date, there has been no investigation into the ISE in the context of nature soundscapes as background noise.

Auditory stimulation during task performance

It has been argued that listening to nature soundscapes can improve cognitive control whilst concurrently performing a task because they have a relaxing effect [8]. This is because being more relaxed enables an individual to attend better to a task and to complete it with more accuracy. If this were true, it could have real benefits for millennial media-multitaskers who may be more sensitive to environmental distractors. However, currently these benefits on cognitive control have not been found. DeLoach and colleagues [8] exposed participants to a rain soundscape for ten minutes whilst they performed a sustained attention task. It was found that there was no difference between performance in the rain condition, white noise, and silence. However, the study employed a short ten-minute test of sustained attention. This type of task may have been insufficiently demanding to find an effect.

Some benefits of background auditory stimulation has been found for people who have attentional deficits, but evidence that these benefits may extend to non-clinical populations is limited. Söderlund and colleagues [39] found that background white noise increased performance on a memory task in children with attention deficit hyperactivity disorder (ADHD). Söderlund and colleagues claimed that the constant background noise actually provided these children with stimulation that aided attention. This benefit of auditory stimulation has also been found in children rated by their teachers as inattentive [37] and is explained by the stochastic resonance phenomenon. According to the stochastic resonance phenomena, random interference (termed 'noise') can increase the detection of weak signals in the brain such that they are more likely to achieve the firing threshold of individual neurons. Signals through the brain may consequently be sent more efficiently.

Given the attentional difficulties associated with heavy media multitasking and the millennial generation, these

benefits of auditory stimulation may also be found in millennials. However, despite evidence that the millennial generation may have difficulty in sustaining attention [46], it is not clear if this attentional deficit is substantial enough to benefit from auditory stimulation. Söderlund et al. [39], (2007) found that children without ADHD were hindered by white noise during task performance. Likewise, Sikström et al. [37] found that children rated by their teachers as attentive were negatively affected by white noise. Therefore, despite these potential benefits of studying whilst in an environment with white noise, this listening behavior may also induce negative effects for already attentive individuals. These negative effects may be caused by unnecessary psychological stress. This is illustrated by the fact that white noise is used as part of a stress induction method in which participants are exposed to various stress inducing stimuli [30]. Furthermore, salivary cortisol levels have been found to be higher for task performance when participants were exposed to white noise compared to when they were in quiet conditions [22]. Furthermore, when participants were exposed to white noise they were more likely to self-report as irritable [22].

One of the reasons why white noise may induce stress is that it is incongruent and unnatural in the working environment. It has been suggested by Campbell and Doman [6] that the brain automatically attempts to identify the source and meaning of sounds in the environment. Sounds that cannot be automatically interpreted, such as white noise, may induce a stress response. Research into the identification of ambiguous sounds has shown that the auditory and visual perceptual systems interact whilst people build a conceptual understanding of their environment [26]. Hunter et al. [12] merged wave sounds from a beach and from a freeway to create an ambiguous wave-like soundscape. Participants heard this soundscape whilst either viewing scenes of a beach or scenes of a freeway. When viewing scenes of a beach, participants self-reported higher levels of tranquillity. An fMRI analysis revealed that the visual stimuli moderated the connections between the auditory cortex and other parts of the brain. This demonstrates the importance of the actual environment for the interpretation of background sounds. This raises questions about the usefulness of nature soundscapes when presented in an incongruent physical environment. No previous research has been conducted in this area.

Overview of the current research

The current research aimed to investigate the use of nature soundscapes by millennial generation students and sought to understand their impact on mood and arousal, cognitive stimulation, and distraction. This research consists of two studies. The first was an experimental study in which the mood and arousal hypothesis and the changing state effect were investigated across different soundscape conditions. The second was a diary study that focused on how millennial generation students felt nature soundscapes

impacted their study performance, mood, and the contextual factors of their use.

Study 1 - Experiment

Previously, no research had been conducted that investigated the effects on task performance of acoustic variation in nature soundscapes that may meet the criteria for the changing-state effect. Therefore, the current study used two different natural soundscapes of different acoustic variation to investigate the effects of changing state on a mental arithmetic task that requires serial recall. The mental arithmetic task used by Banbury and Berry [3] was self-paced, which may have reduced the extent to which participants had to rely upon serial recall. Therefore, the current experiment used an updated version of this task presented by Perham et al. [27] that should force participants to engage in a greater amount of serial recall than the previous version. Given the saliency of both rain noises and birdsong in apps, media reports, and previous research, these soundscapes were chosen for the current experiment. The low acoustic variation condition was a rain soundscape, and the high acoustic variation condition was a birdsong soundscape.

Based on previous research that suggests exposure to nature lifts mood (e.g. [14]) and data that show the popularity of nature soundscape apps and websites [38], the first hypothesis was: *listening to nature soundscapes increases positive mood and cognitive arousal*. Based on previous research that has identified increased arousal and positive mood induced through auditory stimulation can benefit cognitive performance [36], the second hypothesis was: *self-reported positive mood and arousal induced through a nature soundscape is positively associated with performance in a task that requires serial recall*. Finally, based on research that suggests distracting sounds can interfere with the storage of items in STM [28] the third hypothesis was: *a high level of acoustic variation in the nature soundscape decreases performance in a task that requires serial recall*.

Study 2 – Autoethnography and diary study

There are clear limitations to quantitative research when investigating an area of technology use that has received little previous attention. This is because the data may only be relevant to the context in which it was collected. This context may not reflect how nature soundscapes apps are likely to be used by millennial generation students.

The current diary study encouraged participants to explore and create different nature soundscapes, including both constant and intermittent nature sounds. Before the diary study began, a short autoethnographic study was conducted that enabled the researcher to prepare the diary entry forms and to subsequently interpret the data. The main research question of the diary study was: *how does the use of background nature soundscapes impact feelings towards study performance in millennial generation students?* This study had three further sub-questions. The first sub-question

was: *what is the affective experience of millennial generation students whilst listening to nature soundscapes whilst studying?* The second sub-question was: *what are the contextual factors that affect the use of nature soundscapes by millennial generation students?* Finally, the third sub-question was: *what are the preferred elements of nature soundscapes for millennial generation students?*

3. STUDY 1: EXPERIMENT

Method

Participants

Eighteen students born after 1979 (10 male) aged between 23 and 36 (average = 27.94) participated in the current experiment. To facilitate recruitment, participants were included in a draw to win one of three prizes. There was one prize of £50, and two prizes of £25. All participants had normal hearing or corrected-to-normal hearing.

Design

The experiment employed a within-participants design. The independent variable was environmental sound and had three conditions: *silence*, *naturalistic soundscape with low acoustic variation* and *naturalistic soundscape with high acoustic variation*. This meant that there were six orders of presentation of conditions. To counter confounding effects of practice and fatigue, an equal number of participants was assigned to each order of conditions of the independent variable. The dependent variables were *performance on a mental arithmetic task*, *self-reported mood*, and *self-reported arousal*.

The current study also included a non-experimental correlational element that investigated the relationship between both mood and arousal measures compared to performance in the mental arithmetic task in each of the soundscape conditions. Therefore, the variables were measures of arousal (ranging from 0 – 24), mood (ranging from 0 – 32), and performance in the mental arithmetic task (ranging from 0 – 10).

Materials

The arithmetic task was presented on a desktop computer with a 17-inch screen. On the corners of the desk were two Dell AX210CR external speakers. The sound volume was configured so that the speakers produced the soundscapes at 60 decibels. This volume is within the range identified as capable of producing the irrelevant sound effect [42].

The soundscapes were produced using audio files from the British Library. The soundscapes were looped so that they would last for the duration of the experimental session. The low acoustic variation condition was of rainfall [33]. The high acoustic variation condition was of birdsong [43].

The mental arithmetic task replicated that used by Perham et al. [27], comprising 10 addition running-total arithmetic problems. These problems use 15 digits that range from 1-9 and result in end totals that range from 60-99. All digits and operators are presented at a rate of 1.5 second each. The

presentation of one problem takes 30 seconds and the presentation of the entire task takes between 10 to approximately 13 minutes. Digits for each problem were selected using a random number generator. Three tasks comprised of 10 problems each were created for each participant using a bank of 30 problems [Appendix 1]. The problems that comprised each of the three tasks were randomized for each participant. The task was created, presented, and completed by the participants using an interactive PowerPoint presentation.

The current experiment used the approach adopted by Schellenberg and colleagues [36] to measure levels of mood and arousal induced by the different nature soundscapes. Arousal and mood were measured using the Profile of Mood States (POMS) – Short Form [21] [Appendix 2]. The POMS is a validated test in which participants report how they feel different mood-based adjectives describe their current state on a 5-point Likert scale. Although only measures of arousal and mood were analysed in the current study, the entire questionnaire was presented in order to preserve its validity.

Procedure

Participants were sat at a desk in an individual study room and informed that they were going to complete three sessions of basic mental arithmetic tasks and would be asked to answer a short questionnaire about their feelings. The participants were told that the purpose of the experiment was to investigate the effects of nature soundscapes on task performance. The soundscapes, if any, were already playing in the laboratory each time the participant entered for each session. Before the first session, the participants completed one practice trial of the mathematical problem so that they understood the task. Before the experimental session began, the researcher left the room. At the end of each session, the participant was asked to complete the POMS. The participants took approximately 15 minutes to complete each of the three sessions and received a 5-minute break between conditions. At the end of the three sessions, participants received a full debrief in which their rights as a participant were explained again and they were invited to ask any questions that they might have.

Results

Median ratings of negative mood for silence, birdsong, and rain were 1, 0, and 0 respectively. Median ratings of arousal for silence, birdsong, and rain were 5, 7, and 4.5 respectively. Mean average performance in the arithmetic task for silence, birdsong, and rain was 7.22, 6.17, and 7.72 respectively.

The impact of nature soundscape on mood and arousal

No significant differences between soundscape conditions were found in either mood or arousal as measured by the POMS. The data from both the depression/dejection and the vigor/activity sub-scale measures of the POMS questionnaire did not conform to a normal distribution in all

three conditions of the soundscape independent variable. Therefore, these data were considered non-parametric and subsequently were analyzed with a Friedman test. For the depression/dejection subscale of responses, no statistically significant difference was found between either of the soundscape conditions and silence $\chi^2(2) = 1.102, p = 0.576$. Median (IQR) depression/dejection subscale measures for silence, birdsong, and rain were 1 (0 to 3.25), 0 (0 to 1), and 0 (0 to 2.25) respectively.

For the vigour/activity subscale of responses, no statistically significant difference was found between either of the soundscape conditions and silence $\chi^2(2) = 0.123, p = 0.940$. Median (IQR) depression/dejection subscale measures for silence, birdsong, and rain were 5 (0.75 to 10.25), 7 (1 to 11.25), and 4.5 (3 to 9.5) respectively. Whilst the median average subscale measures of arousal suggest a slight trend of birdsong having a positive impact on arousal, this difference was not significant. In summary, nature soundscapes did not affect mood and arousal.

The correlation between mood, arousal, and task performance

The relationship between subscale measures of both vigour/activity and depression/dejection were compared to performance in a mental arithmetic task. Visual analysis of scatterplots (not presented) suggested no monotonic relationship was present for either of these subscales in both the silence and birdsong conditions. Therefore, statistical analyses were not conducted on either of these conditions. A weak linear relationship was identified in the rain condition for both vigour/activity and depression/dejection subscales. Therefore, a Spearman's rank order correlation coefficient was conducted on both the vigour/activity and depression/dejection subscales for the rain condition. There was a very weak negative correlation between the depression/dejection subscale and performance in the mental arithmetic task, which was not statistically significant ($r_s(18) = -.059, p = .812$). There was a very weak negative correlation between the vigour/activity subscale and performance in the mental arithmetic task, which was not statistically significant ($r_s(18) = -.206, p = .413$). Therefore, the current study did not find that measures of mood and arousal were related to performance in the mental arithmetic task.

The impact of acoustic variation on task performance

A one-way repeated measures ANOVA was conducted to compare the effects of background nature soundscapes on correct answers in a mental arithmetic task that requires serialization in working memory. Mauchly's test indicated that the assumption of sphericity had been met $\chi^2(2) = 0.393, p = 0.821$. The results show that there was a significant effect of background soundscape on the amount of correct answers in the mental arithmetic task $F(2, 34) = 5.57, p = 0.008$.

Three post-hoc comparisons were made using paired samples t-tests between conditions. A Bonferroni correction

was applied. A first paired samples t-test revealed that there was no significant difference between correct answers when the maths task was completed with silence ($M=7.22, SD=1.73$) and birdsong ($M=6.17, SD=2.66$) playing as a background soundscape; $t(17)=2.133, p=0.143$. A second paired samples t-test revealed that there was no significant difference between correct answers when the maths task was completed with silence ($M=7.22, SD=1.73$) and rain ($M=7.72, SD=2.16$) playing as a background soundscape; $t(17)=-1.144, p=0.806$. A third paired samples t-test revealed that there was a significant difference between correct answers when the maths task was completed with birdsong ($M=6.17, SD=2.66$) and rain ($M=7.72, SD=2.16$) playing as a background soundscape; $t(17)=-3.154, p=0.017$. Therefore, these results suggest that birdsong negatively impacted performance in the mental arithmetic task when compared to a rain soundscape. However, no difference in performance was found in either birdsong or rain soundscapes compared to silence [Figure 1].

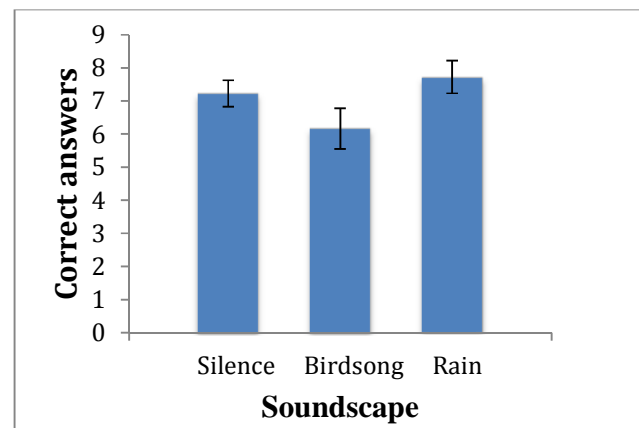


Figure 1. Mean average correct answers and standard error across soundscape conditions.

Discussion

The results of the current experiment have shown that millennial generation students did not report increased positive mood or arousal when performing an arithmetic task whilst listening to a nature soundscape. Furthermore, between participants measures of arousal and mood were not correlated with performance in the mental arithmetic task. Therefore, hypothesis one and hypothesis two of the current experimental study were not supported. However, the third experimental hypothesis was partially supported. High acoustic variation in a nature soundscape was found to negatively impact performance in a mental arithmetic task when compared to a nature soundscape with low acoustic variation. However, the finding that silence did not differ in statistical significance from either of the nature soundscape conditions presents some difficulty in the interpretation of these results.

The current findings do not suggest that the arousal and mood hypothesis is found in nature soundscapes. However, given the very low ratings on the depression/dejection

subscale that was taken as indicative of mood, it is unlikely that there would have been sufficient variance in responses to find any correlation between ratings and task performance. Although measures of arousal may have been more reliable, task performance in the birdsong condition may have been subject to the irrelevant sound effect. Measures of arousal in the silence and rain soundscape conditions may have been the only conditions for which reliable data were gathered to test the arousal and mood hypothesis. However, the fact that no correlations were found in either of these conditions shows that arousal as measured by the POMS was not a factor correlated with task performance. Previous research that has found POMS measures of arousal are related to task performance have used a spatial manipulation task [41] Stanford-Binet IQ tasks and measures of creativity [36]. Therefore, it may be that the benefits of arousal do not generalize to the current task.

In order to understand how millennial generation students may be impacted by nature soundscapes in a non-contrived real-world environment, it was necessary to conduct a longitudinal qualitative study. This approach should reveal how participants describe their experience of the impact nature soundscapes have on mood, cognitive arousal, and stimulation before and during task performance.

4. STUDY 2: AUTOETHNOGRAPHY AND DIARY STUDY

Method

Participants

Initial recruitment was conducted on social media and through friends and colleagues. Five participants took part in the diary study (4 male, 1 female). One of these participants was the current author. The four other participants were paid 25 pounds for participation. All participants were students over 18 and born after 1979. All participants were currently engaged in some form of study for an assessed piece of work. This study required participants engage in periods of study for at least forty minutes, which had to include both reading and writing.

Materials

Many apps provide nature soundscapes. However, the web application naturesoundsfor.me was chosen because it offers a large selection of nature sounds, has a simple word-based menu interface, and has a convenient URL generation function that allows users to save and share their soundscapes. Participants created soundscapes using nature sounds in the sound mixer at naturesoundsfor.me. This sound mixer provides 13 different continuous background nature sounds (rain, waterfall, etc.) and 19 different intermittent sounds (woodpeckers, sheep, etc.) mixed through up to four different channels [Appendix 3].

Participants completed a web diary form constructed and distributed through Google Forms [Appendix 4]. The participants themselves provided materials for studying and for playing the nature soundscapes. The study environment

was chosen by the participant and included both private and public locations.

Procedure

The first phase of this study was a weeklong autoethnographic investigation of background nature soundscapes. In this phase, the researcher used nature soundscapes whilst studying and made notes on his experience. This experience informed the creation of the diary entry form and the participant instructions that were given to participants in the diary study. Before data collection began in the main study, the researcher met participants to explain the study in full and to encourage participants to provide diary entries that were descriptive, open, and unbiased. In addition, participants were provided with an instruction sheet that further explained how they should participate [Appendix 5].

Participants in the diary study were asked to use nature soundscapes on at least four days of a 7-day period. These days were told to the researcher in advance. As such, this allowed the researcher to send a reminder to the participant if they have not completed a diary entry for that day. The period of completion was subsequently extended to 14 days after two participants failed to complete the study in the 7-day period. On each day, participants were asked to construct their own nature soundscape using the website naturesoundsfor.me, and then to save a link to this soundscape. Participants played the soundscape whilst simultaneously engaged in at least 40 minutes of study activity, which included both reading and writing. The participants spent 20 minutes making a diary entry on each day that they used a nature soundscape. This diary entry was made within one hour of the study period. After the participant had made all their diary entries, the researcher conducted an exit interview in which the participant explained their diary entries. This enabled the researcher to gain a deeper understanding of the participant's experience and to clarify any apparent ambiguities or issues that required further exploration.

Data Analysis

The data were analysed using a six-stage thematic analysis technique outlined by Braun and Clarke [5]. This approach acknowledges the role of the researcher in the data analysis process and the unavoidable influence their preconceptions and experiences may have on the resultant findings. The autoethnographic element of the current study means that this factor is of particular importance and was given due consideration during analysis.

A bottom-up inductive approach to data analysis was taken because of the lack of previous research into the experience of nature soundscape applications. The benefits of this approach were that unexpected themes could be identified that may otherwise have been overlooked. These themes could then be considered in terms of the association that they have with the research questions.

The first stage of data analysis involved a comprehensive familiarisation of the data by the researcher. This included transcribing exit interview recordings and reading diary entries several times. Notes about possible themes were made throughout this process. In the second stage of analysis, fourteen initial codes were generated based on each sentence of relevant data. In the third stage, the association between these codes was considered and they were grouped together into three candidate themes. The fourth stage of analysis involved a consideration of the validity of these themes in terms of the individual extracts of data that produced them and their representation of the overall data set. In the fifth stage of data analysis, the explanatory value of each of the themes was considered in terms of the potential of each theme to provide real insight and discussion. This fifth stage involved some iteration and refinement. The final stage of analysis was to create the following results section, in which the themes are presented with short but illustrative examples.

Results

Three overarching themes emerged through the thematic analysis of the diary study and exit interview data. These themes are not discrete but interrelated and each theme contains further subthemes. The first theme is the experience of establishing a sense of control over both the environment and oneself through moderating the auditory environment. The second and third themes relate to the foreground and background experience of the nature soundscapes respectively. The second theme is the incongruence between sound and place, which relates to the *attended* experience of the soundscape. The third theme is the experience of mental stimulation through background nature soundscapes, which relates to the *unattended* experience of the soundscape.

Control over self and environment

A recurrent theme across all participants was the experience of using nature soundscapes to produce a controlled environment. The participants used the soundscape to either establish their own sense of space in a public environment or to create an environment that was conducive to study when they were in a private place. The focus of auditory moderation depended upon both internal and external factors. Internal factors relate to the affective state of the individual and external factors relate primarily to distracting sounds in the environment. As affective state may also be dependent upon environment, the distinction between internal and external factors is not discrete and these factors should be considered interrelated.

The use of nature soundscapes as a sound masker was frequently referred to when participants were studying in an open public place or library environment. This aversion to unpredictable distractions is reflected in the choice of nature soundscapes. When intermittent and segmented sounds were chosen, such as animal and bird sounds, they were done so based on the belief that the sounds would be

predictable and not distracting. In this way, participants believed they were able to create their own study space through a predictable and controllable acoustic environment:

“...I prefer some sound around my ear to block the noise of other people in the environment. So yeah, because this um, this kind of sound comes from one source. So they have the same kind of volume and the same kind of content.”

P2 - Interview

Participants also used nature soundscapes with the intention of controlling or affecting their mood. Overwhelmingly, this was to create feelings of calm and peace. It could be argued that participants were using the soundscapes to assuage negative emotional feelings associated with study, such as stress and anxiety:

“It made me less stressed, I think. Hearing the birds and the running water in the background triggered me to imagine myself sitting on a river bank in the woods, reading or just relaxing. This, I think, allowed me to focus a bit better. I started to think about many different things I had to do, and how they fit together, so I think these nature sounds did help a bit to calm my nerves.”

P3 – Diary

It is clear that there was a strong association between nature and feelings of peace and calm. This association may have been a motivating factor in the way that nature soundscapes were used as mood stabilisers. However, the cause of this association was not identified in the present study. It could be that there is a cultural association between nature and peace or that the pleasantness of the sounds themselves caused the effect. These explanations are not mutually exclusive and both may be factors.

Incongruence between sound and place

One of the most striking findings in the current study was the effect on participants brought about by the juxtaposition of the nature soundscapes compared to the study environment. This juxtaposition was found to create both positive and negative effects. Positive effects seemed to be based on the soundscapes reminding the participants of times when they were connected to nature and had positive experiences in that nature environment:

“...reminded me of taking nature walks back home; I used to go to the mountains and hike through different areas, and the sounds in this link sound similar to what I may have heard during one of my trips. This reminder is nice because I really love going to the mountains.”

P3 - Diary

This incongruence between the environment and the soundscape allowed participants to escape their study environment when consciously attending to the sounds:

“It made me feel distant from the environment I was in (the study room) - and I say this as a good thing, because it sort

of "takes me somewhere else". It also gave me a sense of stability and consistency."

P5 - Diary

However, it is not only feelings of escape that produced these feelings of calm and focus. In contrast, for one participant it was the study environment that was pleasurable in comparison to feelings associated with the nature soundscape:

"It is strange that imagining the harshness of the [soundscape] environment causes me comfort, it must be the juxtaposition - it must be because I am in such warm and cosy surroundings that imagining the opposite gives me comfort"

P1 - Diary

This is interesting because it reveals an alternative view of the general trend of other participants who associated nature with peace and relaxation. Here, nature is harsh and discomfoting. Therefore, it is the separation between the participant and exposure to nature that has produced a comforting effect rather than feelings of being connected to nature.

However, negative affects including uneasiness and discomfort were also found when participants considered the effects of the soundscapes. These included both when the soundscape was incongruent with the outdoor environment and when they were congruent. For example, P5 describes their reaction to a soundscape that occurred when they were already in a nature environment:

"...I was you know in a country house uh with you know birds singing and like so I had the nature sounds available for real, and then like I put the soundscape with the nature sounds and it was very weird, it like was a bit mental you know like I was hearing them, like on the headphones but they were out there so it like..."

Researcher: So did that make you feel uncomfortable?

P5: Yeah, it sort of didn't make any sense because, so what I realised is that they, like the, they're very effective in taking you out of context of your physical environment..."

P5 - Interview

In summary, there were some positive effects on mood brought about when the nature soundscape was consciously attended to. However, it could be argued that the artificiality of the nature soundscapes was a factor that negatively impacted experience. This awareness was brought about by comparisons between the soundscape and the outdoor environment.

Mental stimulation through background nature soundscapes

A distinction should be made between the soundscape as an actively attended to element in the foreground of awareness and the soundscape as a background noise. Emotional responses were the result of deliberately attended to the soundscape in the foreground of attention. It would be

difficult if not impossible to get participants to self-report on any affective reaction they were having to a background sound without bringing the soundscape to the foreground of their attention. As the main focus of the current research is the impact of nature soundscapes on the ability to study, this should arguably be the primary focus in assessing their utility. The main finding in relation to nature soundscapes as a background sound was that they did not sufficiently hold attention to distract participants from their study:

"I did find that during my study session, I often forgot that it was actually playing in the background."

P1 - Diary

This finding may question what the utility of nature soundscapes for studying is beyond their efficacy as a sound masker. However, all participants reported that they did feel they required some form of background stimulation whilst studying, as P4 demonstrates:

"I prefer working in a place where there is a little bit of ambient noise in the background, and like completely silent places kill me, and so in silent places that's where I usually have headphones on like playing a little bit of something"

P4 - Interview

For P4, this usually meant finding a Café to study in, but the first choice of the other participants was music, and this did not change after completion of the diary study. Only one of the participants suggested that they would use a background nature soundscape as environmental stimulation, and that it would not be their first choice:

"Usually when I'm listening to music and I'm studying its classical music... sometimes I just like to switch it up and usually its nature sounds. Just because I find that's probably the next most relaxing thing that I could listen to..."

P3 - Interview

Considering that participants reported listening to a variety of different background stimuli whilst studying, these differences may be linked to the amount of stimulation an individual requires. The use of background soundscapes may therefore be subject to individual differences. The following example shows the contrast between the description of P3 (above), who prefers relaxing sounds, and P5:

"...after a while I feel it is a bit numbing. I don't get bored or sleepy, but it doesn't stimulate my mind (I usually listen to upbeat music or music with high intensity while studying)"

P5 - Diary

Nature soundscapes served as non-invasive background auditory stimulation for the study session. In this way, it was like a signpost that the individual had set up their environment for study. Therefore, this theme is closely related to, and could be considered a product of, the first theme of control over self and environment.

Discussion

This discussion shall consider how each of the above themes can be applied to the research question and sub-questions.

The main research question was: *how does the use of background nature soundscapes impact feelings towards study performance in millennial generation students?* In general, millennial generation students reported that nature soundscapes had a positive impact on their ability to study. This was because they reported both an aversion to silence and to auditory distractors. In this way, the nature soundscapes were both cognitively stimulating and acted as a sound masker. Therefore, background nature sounds may be used to create a personal environment conducive to studying in a public or private place. However, participants did not report that they would prefer nature soundscapes above their currently preferred soundscape, such as non-attention grabbing music.

The second research question was: *what is the affective experience of millennial generation students whilst listening to nature soundscapes whilst studying?* Most participants reported that nature soundscapes were a useful resource for achieving feelings of calm and peace. Furthermore, the sounds allowed them to control their affective state and keep it stabilised. When the sounds were actively attended to, they were often evocative of past experiences with nature. This meant that the affective experience was a very personal one and it would therefore be difficult to suggest that one type of soundscape was better than another. Participants selected which nature sounds to listen to, and as such it is not possible to compare affective experiences across similar soundscapes in the current study.

The third research question was: *what are the contextual factors that affect the use of nature soundscapes by millennial generation students?* In considering this question, it was found that comparisons with the outdoor environment were important. An awareness of the artificiality of the soundscape when compared to the outdoor environment produced reactions of discomfort and uneasiness. Incongruence with the outdoor environment also had some pleasurable effects because participants were able to escape their current environment. Other contextual factors included the need for sound masking in a public place, and the need for stimulation. However, the degree to which soundscapes were found to be stimulating depended upon the individual.

The fourth research question was: *what are the preferred elements of nature soundscapes for millennial generation students?* It was found that the students preferred a nature soundscape that had matching elements and a subsequent sense of realism in terms of what might be found in the real world. What elements were preferred also seemed to depend on the associations that participants had with each sound. These associations depended in part upon previous experiences that the participant had. All participants liked

continuous background sounds but intermittent sounds were viewed differently across participants.

5. GENERAL DISCUSSION

Millennial generation students may find some benefits in using nature soundscapes as background noise whilst studying. This is because these soundscapes enable students to have a degree of control over themselves and their auditory environment. Nature soundscapes can be cognitively stimulating, stabilise mood, and mask distracting environmental sounds. However, high acoustic variation in the form of intermittent and segmented sounds can distract attention. The extent to which this interferes with the task of studying may depend on what activities are being engaged with. In particular, tasks that require the serialisation of items in working memory may be negatively affected by distracting sounds. This general discussion considers each element of the current research in turn, and includes recommendations for the design and use of nature soundscapes in technology and workspace design.

The impact of nature soundscapes on mood, arousal, and stimulation

The current experimental study does not suggest that arousal and mood are affected by nature sounds in the same way that they are affected by music (e.g. [36]). Furthermore, there was no difference of performance in the mental arithmetic task between the silence conditions and either of the nature conditions. There was no 'nature effect' identified in the same way that there has been a 'blur effect' [35] and a 'Stephen King effect' [23]. However, these studies used a spatial manipulation task and not an arithmetic task, which may explain the current results. However, the lack of significant differences in ratings on the POMS suggests that the experience of listening to nature soundscapes may be fundamentally different to the experience of listening to other auditory stimulation. Previous research has identified that mood and arousal are dissociable factors that may influence task performance independently [36]. Therefore, mood and arousal shall be considered individually in the context of nature soundscapes.

It was hypothesized that nature soundscapes would increase positive mood. The nature soundscapes in the experimental study did not have a significant effect on mood. This finding is in contrast to previous studies that found an association between nature exposure and positive mood (e.g. [14]). However, it may be that the degree to which participants in the current experiment felt exposed to nature was limited. As such, the exposure they received was not sufficiently large enough to have an effect. This may be because of the laboratory conditions in which the experiment was conducted. There was a clear juxtaposition between an auditory nature environment and a cubicle laboratory containing only a computer, speakers, and no windows or natural light. The diary study revealed that an awareness of the artificiality of the nature soundscape occasionally led to participants feeling uncomfortable and

uneasy. The experiment was conducted in a built-up area of London on a dry summers day. Therefore, the mismatch between the interior and exterior environments compared to the soundscapes may have meant participants felt disengaged with the nature sounds.

Although mood was not found to be affected as measured by the POMS in the experimental study, diary entries and interview transcripts revealed that participants did feel in some way emotionally affected by their nature soundscapes. Predominantly, this effect was described as the nature soundscapes having a calming and stabilising effect on mood. As such, it would be unlikely that positive mood would be increased or negative mood decreased when listening to a nature soundscape. In fact, it could be argued that if nature soundscapes only produce a stabilising effect on mood, then this would prevent an increase in positive mood. This may explain why no effect was found in the experimental study.

In the diary study, descriptions of the impact on mood occurred when the soundscapes had to be at the foreground of attention. In the experimental study, it is unlikely that the soundscapes were at the foreground of attention for any substantial period of time. It is important to note that the current experiment differed to studies that have measured the impact of music with the POMS. In previous studies, the auditory stimuli were actively attended to for a brief period of time before task performance. It could be argued that when the students were in the experiment, the nature soundscape was not as actively attended to as in the diary study. In contrast, creating the nature soundscape in the diary study would have meant that the participants were actively attending to and subjectively evaluating the soundscape for some time before beginning their study period. Furthermore, in the diary study, students created the soundscape themselves. As such, this may have meant they chose soundscapes that they emotionally responded to.

According to Schellenberg et al. [36] arousal has a greater impact on subsequent task performance than mood. However, the current study did not find any differences in arousal across the three conditions using the POMS. It is clear though from the diary study and interview data that millennial generation students needed some form of background noise for stimulation. However, stimulation and arousal are not necessarily the same thing. This is demonstrated by the stochastic resonance explanation put forward by researchers such as Sikström et al. [37], to explain why auditory stimulation may have benefits for people with attentional deficits. This is in contrast to the arousal effects of music that occur prior to task performance.

In the diary study, participant's descriptions of using background sounds as stimulation was linked to maintaining focus and attention. This correlates well with previous research that shows auditory stimulation helps to maintain attention for some people [37, 39]. However, this

previous research used clinical and sub-clinical populations with identifiable attention deficits. Previous research shows that millennial generation students may have attentional deficits caused by habitual media multitasking behaviour [46]. Therefore, it could be that participants in the current research may be a population with some degree of attention deficit. In support of this, it was found that participants in the diary study reported that they were able to use nature soundscapes to self-stimulate and maintain attention. However, participants in the current study were not controlled for previous multitasking behaviour or ability to maintain attention. Therefore, the claim that millennial generation students can use auditory stimuli to aid concentration would need further investigation.

Irrelevant and distracting sounds

As predicted, a nature soundscape condition with high acoustic variation had a negative impact on performance in an arithmetic task that requires serialization compared to a soundscape with a low acoustic variation. Therefore, these findings suggest that an irrelevant sound effect can occur when millennial generation students use background nature soundscapes. However, the finding that neither of these conditions differed in terms of statistical significance from the silence condition raises interesting questions. True silence could not be achieved in the laboratory cubicle. As such, occasional noises from other cubicles in the room may have distracted participants and caused an unintentional irrelevant sound effect. This would not have been present in the rain soundscape condition because it would have acted as an auditory masker. However, these uncontrollable noises were very infrequent and very quiet. Although it is unlikely that they had an effect, it cannot be ruled out.

In contrast to the experiment, the diary study revealed that in general participants did not feel that intermittent sounds were particularly distracting. However, they could be if the sounds possessed attention-grabbing qualities, such as being of a relatively high volume compared to the overall soundscape. The masking qualities of the soundscapes meant that they were positively evaluated for use in an environment with unpredictable auditory distractions. Subsequently, they may offer an alternative to white noise with the additional benefit of the user believing that they stabilize mood.

Context, environment, and listening choices

Congruency between sounds and congruency of the sounds with the environment were found to be an important factor of what choices participants made in the diary study and what their subsequent evaluations and affective reactions were. As this was the first study of its kind, this is an important finding that should shape both the design of nature soundscape apps and the introduction of these soundscapes into workplace design. Incongruency with the outdoor environment and between sounds can negatively impact experience. This finding could be explained by

previous research that suggests sounds are automatically interpreted based on the environment [12]. As such, it is not surprising that the diary study revealed some participants had a sense of uneasiness when sound and environment were not congruent. However, the link between positive emotional reactions and the ability to have a feeling of escape from the working environment depends upon incongruence with the physical environment. Therefore, the importance of individual differences and choice for subsequent users of this technology should be a primary factor of its design. In addition, given the finding of the diary study that the nature soundscapes can be used for the creation of a personal working environment, an approach for workplace designers might be to allow an individual to use soundscapes to mark their own space. This might be a way to communicate to others that they are currently focussed on a task and do not want to be disturbed.

Biophilia in technology and workplace design

The use of natural elements in technology and workplace design has become a focus for some ergonomists who believe that they may have a beneficial impact on wellbeing [32]. Some findings from the diary study support this approach, especially the impact the soundscapes had upon feelings of calm and peace. This impact is in line with previous research that has identified the restorative qualities of exposure to nature sounds [1]. However, in the interviews participants did not show a preference for nature soundscapes over other possible ambient sounds. Furthermore, positive responses to nature soundscapes were strongly associated with the evocation in memory of pleasurable past experiences. This suggests that these positive responses are more likely to be a result of actual experience that happened to occur in the context of nature surroundings rather than by the nature exposure itself. For nature soundscapes at least, this questions the validity of explaining the benefits of exposure to natural elements in terms of evolutionary disposition.

Limitations and further research

It may be that any differences in arousal and mood were not measurable using the POMS. This could be because they are either qualitatively different to the effects of music listening or too subtle for the POMS to pick up. With regard to this latter possibility, it is notable that the version of the POMS used in the current experiment includes six words that provide the subscale score for vigor/activity and eight words for depression/dejection. It could be argued that this was not sufficient. Furthermore, mood is only measured by the POMS in terms of depressive and negative states and therefore uses only negative words (blue, worthless, etc.). Given the median values found in the present study in this subscale were zero and close to zero (0, 0, 1), this measurement may have failed to pick up changes in positive mood because responses were already at the maximum level that the POMS questionnaire allows for. Unfortunately, previous research that has used the POMS in relation to music listening did not publish average scores on

the subscale (e.g. [36, 41]). As such, a comparison with the current data cannot be made. This is important because it seems unlikely that healthy individuals would be likely to score high on a measure of negative mood that includes responses to words such as 'worthless', 'helpless', and 'hopeless'. Therefore, future research should utilize other methods to capture self-reported positive mood.

The current experimental study differed from previous studies that have used the POMS to measure mood and arousal before and after exposure to a single stimulus. However, the current study did include a silence condition that should have been representative of non-exposure to auditory stimuli. Despite this, it could be argued that any impact on mood and arousal caused by exposure to the nature soundscapes were still present in other conditions. Furthermore, whilst participants took breaks between conditions, these breaks may have been too short. As such, preceding conditions may have influenced participants who received the silence condition second or third. This may account for a lack of difference in mood and arousal ratings across conditions. Further experiments could adopt between participant designs to eliminate this problem.

The fact that performance was worse in the birdsong condition compared to the rain condition, but not compared to the silence condition may suggest that the rain condition stimulated participants in a way that aided concentration. However, this cannot be concluded from the findings of the current experiment. A further experiment could be conducted to investigate this claim that specifically focuses on sustaining concentration and compares populations of low and high concentration abilities.

6. CONCLUSION

Nature soundscapes in apps and workplace design may give millennial generation users an opportunity to create an auditory environment that they find is conducive to work or study. Listening to nature soundscapes does not have the same impact on mood and arousal that listening to music does. This may be because nature soundscapes have a calming and stabilizing effect rather than an uplifting effect. The experience of listening to nature soundscapes may be highly personal and could depend upon the associations an individual makes between the sounds and their personal experience. As most people experience nature during leisure and recreation these associations are likely to be positive. However, nature soundscapes do have the potential to make listeners uneasy and uncomfortable. This may occur when users are in an environment in which the nature sounds appear artificial or are not congruent with the environment. The composition of nature soundscapes should not include high acoustic variation or segmented sounds because this can cause distraction through the unintentional capture of attention.

The current research found that millennial generation students might have a preference for background auditory stimulation. However, the current diary study only used five

participants. In order to understand if any preference exists this claim needs to be investigated with a larger scale quantitative study. This would be an important area to research because it relates to potential differences in attentional processing caused by habitual media multitasking behavior. A breadth-based attentional profile may benefit from auditory stimulation, which may explain why participants had an aversion to silence.

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APPENDIX 1: MATHS TASK

- (1) $6+1+2+2+5+5+9+7+2+6+2+4+4+4+8 = 67$
- (2) $2+7+6+6+8+1+4+2+1+2+7+1+4+1+8 = 60$
- (3) $5+6+8+2+6+1+1+9+9+3+9+5+7+9+7 = 87$
- (4) $9+9+1+3+5+8+3+8+1+1+3+7+4+9+4 = 75$
- (5) $7+7+1+9+9+2+3+9+4+9+4+7+9+4+6 = 90$
- (6) $2+8+6+6+9+3+6+2+4+6+5+4+1+1+2 = 65$
- (7) $9+9+9+1+1+7+4+7+1+8+7+2+3+3+5 = 76$
- (8) $1+9+9+7+2+2+1+3+2+4+9+9+5+5+3 = 71$
- (9) $4+3+7+8+3+2+1+4+5+5+7+7+1+7+5 = 69$
- (10) $9+9+4+4+4+9+2+7+9+5+2+2+9+2+4 = 81$
- (11) $6+4+5+8+4+1+5+4+9+8+2+3+2+4+3 = 68$
- (12) $1+9+2+7+1+9+1+2+1+2+9+1+6+5+5 = 61$
- (13) $5+1+7+1+1+9+3+8+6+5+5+8+1+1+9 = 70$
- (14) $5+3+1+8+6+6+8+7+2+6+1+4+5+2+1 = 65$
- (15) $4+1+9+1+5+4+1+8+6+7+9+2+4+7+3 = 71$
- (16) $3+3+5+8+1+1+7+3+7+4+3+4+8+5+2 = 64$
- (17) $4+2+8+4+9+6+2+5+6+8+3+7+3+6+5 = 78$
- (18) $7+2+6+7+1+8+5+8+8+6+2+6+9+6+9 = 90$
- (19) $6+7+6+8+3+5+3+7+8+8+7+7+9+5+1 = 90$
- (20) $3+7+6+2+7+2+7+9+6+7+2+4+9+8+7 = 86$
- (21) $1+2+5+3+6+8+2+8+1+6+5+7+2+1+4 = 61$
- (22) $4+6+3+2+6+9+9+2+9+4+8+5+5+1+6 = 79$
- (23) $2+2+4+1+7+7+5+1+5+8+8+5+3+1+3 = 62$
- (24) $4+9+7+4+3+3+9+8+8+9+7+1+8+2+1 = 83$
- (25) $8+3+3+7+9+1+2+3+4+1+3+2+1+8+5 = 60$

$$(26) 8+6+6+3+8+2+7+4+2+4+9+7+6+1+4 = 77$$

$$(27) 8+3+2+1+9+7+4+3+9+7+8+7+2+4+2 = 76$$

$$(28) 6+8+3+6+1+2+4+9+6+4+2+6+7+2+1 = 67$$

$$(29) 2+4+7+2+4+8+3+1+9+7+3+6+1+4+5 = 66$$

$$(30) 8+4+8+7+8+7+1+5+8+9+7+5+2+8+2 = 89$$

APPENDIX 2: QUESTIONNAIRE WITH POMS

Questionnaire

Please enter your participant ID (this is on the small piece of paper that the researcher gave you)

What is your age?

What is your gender?

Female

Male

Other :

In which of the three experimental sessions are you?

First

Second

Third

Below is a list of words that describe feelings.

Please read each one carefully.

For each word, select ONE statement from the column that best describes how you are feeling RIGHT NOW.

Not at all. A little. Moderately. Quite a bit. Extremely.

Tense

Angry

Worn out

Unhappy

Lively

Confused

Peeved

Sad

Active

On edge

Grouchy

Blue

Energetic

Hopeless

Uneasy
Restless
Unable to concentrate
Fatigued
Annoyed
Discouraged
Resentful
Nervous
Miserable
Cheerful
Bitter
Exhausted
Anxious
Helpless
Weary
Bewildered
Furious
Full of pep
Worthless
Forgetful
Vigorous
Uncertain about things
Bushed

APPENDIX 3: NATURE SOUNDS AVAILABLE IN THE WEB APPLICATION NATURESOUNDSFOR.ME

Nature: beach, creek, fire, forest ambience, fountain, rain, rain (heavy), rain on roof, snowstorm, thunder, water drops, waterfall, waterfall 2, wind in leaves.

Birds: forest birds, loon, owls, seagulls, whip-poor-will, woodpeckers.

Mammals: cat purr, dog panting, horse snort, lemur, sheep, whale, wolves.

Other animals: bee colony, cicadas, crickets, frogs, grasshopper, spring peepers.

APPENDIX 4: DIARY ENTRY FORM

Nature soundscape diary study

Please complete this form each day that you participate.

* Required

Please enter your participant ID if you give consent for this diary entry to be used by the researchers: *

Which of the four days of participation is this? *

Day 1

Day 2

Day 3

Day 4

Please copy and paste the link to your nature soundscape that you created at naturesoundsfor.me *

Why did you choose these sounds?

Please describe the environment in which you were studying.

Did this environment have any impact on what soundscape you listened to? If yes, please explain why.

How did you listen to the soundscape (i.e. speakers, headphones)?

For how long did you study and listen to this soundscape?

Did listening to this nature soundscape affect your mood in any way? If yes, please describe your feelings in as much detail as you can.

Did this nature soundscape have a positive, negative, or neutral effect on your ability to study? Please describe why in as much detail as you can.

APPENDIX 5: DIARY STUDY PARTICIPANT INSTRUCTIONS

How to take part in the diary study

What is the study about?

This diary study has one main research question: How does the use of background nature soundscapes impact feelings towards study performance in millennial generation students?

..and three sub-questions:

(1) What is the affective experience of millennial generation students when listening to nature soundscapes whilst studying?

(2) What are the contextual factors that affect the use of nature soundscapes by millennial generation students?

(3) What are the preferred elements of nature soundscapes for millennial generation students?

In sum, the point of this study is to see what benefits and handicaps are created when studying in an environment with nature sounds.

What you will do as a participant

You will need to participate on four days. These can be any days you choose, but please ensure you have finished the diary study by Sunday July 10. For each day that you participate, you will need to complete three steps:

Step one

Go to the website naturesoundsfor.me. Here you will find a sound mixer with four channels. Each channel is identical and contains a dropdown menu with different sounds to choose from. Some of these are continuous (such as rain) and some are intermittent (such as animal noises). You should use these sounds to create your own nature composition. It is entirely up to you how many of the channels you use and what sounds you choose, but please only use the nature sounds. Once you have created a composition that you are happy with, click the 'Save as Link' button and create a link to the composition as an anonymous user. Please create a different composition on each of the four days of participation, one per day. What you create is entirely your choice.

Step two

Study as normal whilst you play the soundscape in the background, this can be through speakers or headphones. Please ensure that you study like this for at least 40 minutes on each day of participation. Your study session should include both reading and writing activities.

Step three

Please complete the diary entry form at

https://docs.google.com/forms/d/1N7E57to5dIdqNv-fzWQTTPIcfK9yFuIe3GNjzZnMz_Q/viewform

You should do this within one hour of your study session. Please aim to spend around fifteen to twenty minutes completing the diary entry for that day. When you write your answers, please be as open and honest as possible. You should write everything and anything that comes to mind. In my experience, it may help to write in a 'stream of consciousness' style in which you write down all thoughts and feelings that cross your mind as they occur to you. The benefit of this approach is that there is less chance that you will give responses based on what you may believe the researchers expect. Subsequently, this will make your responses more true to your actual experience. It also makes writing your diary entries much more enjoyable and unconstrained.

After the four days

Once you have completed all of your diary entries we will have a brief conversation on Skype or face-to-face at UCL. This conversation will be to ensure that I have fully

understood your experience and for you to ask any questions. It will also be a debriefing session for the study. Part of the conversation will be recorded, and it may be used for analysis in the study.

On the following two pages are a participant information sheet and a participant consent form. These are for you and you do not need to return them to me. You will be giving me consent to use your data by entering your participant ID into each diary form.

If you have any further questions please do not hesitate to contact me. Otherwise, you are free to go ahead and begin the study. I thank you for your participation.