This is the accepted version of the following article: Markwell N, Gladwin TE (2020). Shinrin-yoku (forest bathing) reduces stress and increases people's positive affect and wellbeing in comparison to its digital counterpart. Ecopsychology, 12 (4), which has now been formally published in final form at Ecopsychology at https://doi.org/10.1089/eco.2019.0071. This accepted version of the article may be used for non-commercial purposes in accordance with the Mary Ann Liebert, Inc., publishers' self-archiving terms and conditions.

Shinrin-yoku (Forest Bathing) Reduces Stress and Increases People's Positive Affect and Wellbeing in Comparison to its Digital Counterpart

Natalie Markwell [a*], Thomas Edward Gladwin [ab]

[a] Department of Psychology and Counselling, University of Chichester, College Lane, Chichester, PO19 6EN, United Kingdom. NM: natalie.markwell@yahoo.com TEG: T.Gladwin@donders.ru.nl

[b] Radboud University Nijmegen, Nijmegen, The Netherlands

* E-mail: natalie.markwell@yahoo.com
Address: Bishop Otter Campus, College Lane, Chichester, PO19 6PE, United Kingdom.

Manuscript Keywords
Shinrin-yoku, Nature, Stress, Wellbeing, Positive Affect, Negative Affect

Abstract

Separation from nature may contribute to stress and reduced wellbeing. Shinrin-yoku may be an effective and cost-effective method to improve mental health by immersion in forests/woodlands. The current study experimentally tested the effect of Shinrin-yoku on stress, affect and wellbeing and sought to gain further insight into the experience of participating in Shinrin-yoku. A mixed methods experimental design was used to conduct the study. 22 participants, stratified by hand, were assigned to one of two conditions: the actual nature (Shinrin-yoku) condition and the digital nature (digital Shinrin-yoku) condition. Scales were used to measure four aspects of mental health: stress, positive and negative affect, and wellbeing. Participants completed four hour-long sessions and questionnaires were completed at four-time points: baseline, two-week point, post intervention and one-month follow-up. A mixed between-within ANCOVA was used to analyse the questionnaire data. Additionally, participants took part in interviews and gave answers to open-ended questions, which were analysed using thematic analysis. Actual Shinrin-yoku was found to increase positive affect and wellbeing significantly more than the digital Shinrin-yoku condition. This significant difference for positive affect between the two conditions remained at the one-month follow-up. A number of themes were identified characterizing similarities and differences between the Shinrin-yoku and digital Shirin-yoku conditions. Positive emotions were experienced in both conditions, but whilst Shinrin-yoku was associated with mental refreshment, the digital Shinrin-yoku condition was associated with loss of concentration.

Keywords

Shinrin-yoku, Nature, Stress, Wellbeing, Positive Affect, Negative Affect

Author Disclosure Statement

No competing financial interests exist.

1. Introduction

Stress can lead to high blood pressure, obesity, anxiety, depression and addiction, to name a few consequences (Harvard Health, 2016; NHS, 2017; Frumkin et al., 2017). Additionally, stress is negatively correlated with executive cognitive functions, affecting work and interpersonal relations (Steptoe & Feldman, 2001). Stress affects not only individuals and those close to them but also businesses, public health services, and the economy. For instance, in 2018/19 12.8 million working days were lost due to stress, anxiety or depression in the UK and within Europe, stress is estimated to cost the economy over €188 billion annually (HSE, 2019; Cox et al., 2017;). Thus, interventions that could successfully decrease stress are needed. Furthermore, an intervention that is easily accessible, with no known side effects and minimal cost would be even more beneficial. Berman, Jonides & Kaplan (2008) propose that such an intervention has been known to philosophers and environmentalists for centuries: spending time in nature.

Indeed, studies have shown that spending time in nature has a number of beneficial effects on mental health: it reduces the stress hormone cortisol whilst increasing positive feelings and emotions (Sung et al., 2012; Ochiai et al., 2015;Aerts et al., 2018); improves cognitive function and reduces attentional fatigue (Kaplan, 1995; Berto, 2005; Berman et al., 2008; Mayer et al., 2009); and reduces stress (Ulrich, 1991, 1983; Martyn & Brymer, 2016). Positive correlations have been found between nature connectedness and positive health and wellbeing, in accordance with the biophilia hypothesis (Grinde & Patil, 2009; Chen, 2017). However, as our world becomes ever more reliant on technology; the human disconnection from nature has

become greater (Hand et al., 2017; Kahn, 2009). This separation from nature may contribute to stress and stress related diseases (Soga & Gaston, 2016; Meidenbauer et al., 2019; Rogers, 2019; Bratman et al., 2019). Furthermore, technological approximations of being in nature may not confer the same level of benefits (Kahn et al., 2008).

The current study looks to understand this further and explore the differences, if any, of being present in nature compared to experiencing nature digitally to improve mental health, i.e., to reduce stress, increase positive affect and wellbeing. The study uses Shinrin-yoku, an originally Japanese intervention translating to "taking in the forest environment or forest bathing." Shinrin-yoku is typically done in silence and involves spending time in woodland or forest, removing all distractions and wandering aimlessly (Shinrin-yoku, 2017). Research has shown Shinrin-yoku has both physiological and psychological benefits that contribute to stress reduction (Park et al, 2010; Sonntag-Öström et al, 2015; Morita et al, 2007; Tsunetsugu et al, 2010). Empirical support for Shinrin-yoku as an effective intervention for stress was found in a review of the literature (Hansen et al. 2017) which also highlighted that with the majority of Shinrin-yoku studies being conducted in Asian countries, more research needs to be conducted in other cultures such as the West to strengthen support for its effectiveness worldwide.

Therefore, this current study seeks to explore how conducting Shinrin-yoku in nature compared to digitally simulated Shinrin-yoku impacts its potential effectiveness as an intervention to reduce stress. Through this, it also seeks to show that an intervention such as Shinrin-yoku does have a place within Western culture.

It is hypothesized that spending time in actual nature to conduct Shinrin-yoku will reduce stress and improve affect and wellbeing even at a follow-up time point, relative to the digital Shinrin-yoku condition. Further, qualitative methods will be used to gain a deeper understanding of how participants experience Shinrin-yoku in both formats, which may provide clues as to the underlying mechanisms.

2. Material and methods

2.1. Participants

Participants were recruited via social media and printed posters placed around the local community and university. Participants were required to be over the age of 18 and comfortable to walk around a woodland setting. A total of 22 participants (males = 4, females = 18) participated and completed all four sessions of the study. This sample size would require a large effect size (0.4) to have around 90% power to detect the main group by time interaction of interest, as estimated using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). This will be discussed further and is acknowledged as a limitation, but we briefly note that the relatively low sample size should be seen in the context of the practical considerations of the experimental design, the stratification procedure, and the inclusion of qualitative methods. Ages ranged from 19-65 years old (M= 36.00, SD = 15.55) with all participants being full time employed or full-time students (number of students = 10; number of full-time employed = 12). The study was approved by the ethics committee for the University of Chichester. Participants' informed consent was obtained before they took part in the study. Due to the experimental nature of the design, specific details of the study

were omitted to reduce potential biases, but all participants were fully debriefed at the end of the study. In order to comply with data protection and confidentiality; all participants were anonymised into a participant number and all identifying information was held securely in a password protected document.

2.2. Design

The study followed a mixed methods experimental design (Creswell & Clark, 2007). Qualitative methods were used to explore participants' experiences of the study. Quantitative methods were used to test differences between a Shinrin-yoku and digital Shinrin-yoku group. Participants were stratified by hand into one of the two conditions, to reduce random noise and the risk of confounds between groups. For the purposes of this study, participants were stratified by hand on age, gender and occupation (Table 1).

2.3. Materials

2.3.1. Positive and Negative Affect Schedule. This 20-item scale (PANAS, Watson et al., 1988) split into 2 separable 10-item positive and negative affect scales was used to assess the participants' state affect. The scale consists of a number of words to describe positive feelings and emotions, such as enthusiasm, excitement and determination, and negative emotions or feelings, such as distress, anger and fear. Participants rated to what extent they presently felt each emotion using a Likert scale (1 = slightly or not at all; 5 = extremely); the higher the total score, the more positive/negative the participants' state affect and consequently the lower/higher the levels of stress. Sample items include 'indicate to what

extent you feel this way right now, that is, at this present moment: interested'. The PANAS is a reliable and valid measure (Crawford & Henry, 2004). In this sample, Cronbach's alphas were .92 (positive affect) and .88 (negative affect).

2.3.2. Warwick-Edinburgh Mental Well-being Scale. This 14-item scale with 5 response categories (WEMWBS; NHS Health Scotland, University of Warwick and University of Edinburgh, 2006) was used to assess participants' positive mental health and wellbeing. Participants rated on a Likert scale (1 = none of the time; 5 = all of the time) how best the positively worded statements described their experience of the past two weeks. The higher the total score, the lower the levels of stress and the more positive the mental health and wellbeing for participants. Sample items include 'I've been feeling relaxed'. The internal consistency for the WEMWBS has shown to fall well above the recommended Cronbach alpha coefficient of .7 in previous studies (Tennat et al, 2007; DeVellis, 2012). In this sample, similar results were found with a Cronbach's alpha of .94

2.3.3. Perceived Stress Scale. A widely used psychological instrument for measuring the perception of stress (PSS; Cohen, 1994), this 10-item scale was designed to measure the degree to which a participant found situations in their life stressful during the last month. Participants were required to rate how often they felt or thought a certain way using a Likert scale (0= never; 4= very often). The lower the total score, the less perceived stress experienced by the participant. Sample items include 'in the last month how often have you felt nervous or "stressed"?' Regarded as a reliable and

valid instrument for measuring perceived stress; in this sample the Cronbach's alpha was quite low (.5) (Roberti et al, 2006). However, this is regarded as quite common in scales with ten or less items (Pallant, 2013).

Open-ended questions at the end of the two-week time point and post intervention questionnaires, and semi-structured interviews were used to obtain the qualitative data for this study. The questions aimed to explore the participants' experience of the sessions they attended in order to begin to unpick the mechanisms behind the stress restoration effects of forests. Questions were guided by the participants responses but in the context of seeking to understand and generate themes from: 1) How they found the session 2) What they liked and disliked about the session 3) What they found and didn't find beneficial about the session

2.4. Experimental Procedure

Within the stratification scheme participants were placed at random in one of two conditions: the actual nature (Shinrin-yoku) condition and the digital nature (digital Shinrin-yoku) condition. To take part in the study, interested participants contacted the researcher who then assigned them to either the true nature or digital nature condition.

For the Shinrin-yoku group, participants attended four hour-long sessions, once a week for four consecutive weeks. To ensure safety and convenience, the researcher and willing participants drove the remaining participants to the nature reserve site each week (Figure 1). Despite this group travel, participants conducted Shinrin-yoku

in silence and after initial guidance on what to do, completely on their own. The researcher then met them once the session had finished.

The digital Shinrin-yoku group were sent links to an hour-long forest video session once a week for four consecutive weeks. The video was created by the researcher and mimicked a Shinrin-yoku session, allowing the viewers to see trees and different animal species, as well as hear the sounds of spending time in a forest (Figure 2).

Links to online questionnaires created on Qualtrics were sent via email to participants at four different time points: baseline (demographic information, PANAS, PSS, WEMWBS), two-week time point (PANAS, WEMWBS), post intervention (PANAS, PSS, WEMWBS) and one month after the final session was attended (PANAS, PSS, WEMWBS).

2.5. Statistical Analysis

For the quantitative part of this study, the data were analysed in SPSS with a mixed between-within design analysis of covariance with within-subject factor time (two-week time point, post intervention and one month follow-up) and between-subject factor experimental group (Shinrin-yoku or digital Shinrin-yoku). Separate analyses were run for each of the four outcome measures (PSS, positive and negative scales of the PANAS, WEMWBS) used in this study. The respective measures' levels at the baseline time point were used as covariates. For the qualitative part of this study, thematic analysis was used to encode the data in order to identify themes in answer to the research question (Braun & Clark, 2006).

3. Results

3.1. Quantitative Analysis Results.

No violation of assumptions was found for any of the analyses.

3.1.1. PSS.

There was no main effect of time, $F(1, 19) = .00$, MSE= 28.33, $p = .99$, $\eta_p^2 = .00$, or condition, $F(1, 19) = .26$, MSE= 26.93, $p = .61$, $\eta_p^2 = .01$. There was a non-significant trend for the interaction effect between condition and time, F(1,19)=4.1, MSE= 28.33, $p = .057$, $\eta_p^2 = .18$.

For exploratory purposes, effects of condition were tested per time point. At post intervention there was no significant difference between perceived stress in the Shinrin-yoku condition (M = 15.64, SD = 4.18) than in the digital Shinrin-yoku condition (M = 18.36, SD = 5.55), $t(20) = -1.30$, $p = .21$, two tailed, 95% CI[-7.10 to 1.64]. At the one-month follow-up, there was no significant difference between perceived stress in the Shinrin-yoku condition (M = 26.45, SD = 5.72) than in the digital Shinrin-yoku condition (M = 23.20, SD = 6.38), $t(20) = 1.27$, $p = .22$, two tailed, 95% CI[-2.12 to 8.66].

3.1.2. PANAS (positive affect).

There was no main effect for time, $F(2, 38) = .18$, MSE= 43.17, $p = .84$, $\eta_p^2 = .00$ and no significant interaction effect between condition and time $F(2, 38) = 1.002$, MSE= 43.17, $p = .38$, $\eta_p^2 = .05$. There was a significant main effect of condition, F (1,19) = 7.15, MSE= 162.40, $p = .015$, $\eta_p^2 = .27$. The level of reported positive affect was greater in the Shinrin-yoku condition (M = 28.28, SE = 2.28, 95% CI[23.51 to 33.05])

than in the digital Shinrin-yoku condition (M = 19.45, SE = 2.28, 95% CI[14.68 to 24.22]).

For descriptive purposes, effects of condition were tested per time point despite the non-significant interaction. At the two-week time point, there was no significant difference between positive affect in the Shinrin-yoku condition (M = 29.09, SD = 10.87) than in the digital Shinrin-yoku condition (M = 20.45, SD = 9.64), $t(20) = 1.97$, $p = .06$, two tailed, 95% CI[-.50 to 17.77]. At post-intervention, positive affect was higher in the intervention condition (M = 30.36, SD = 9.67) than in the digital Shinrin-yoku condition (M = 17.81, SD = 11.50), $t(20) = 2.77$, $p = .012$, two tailed, 95% CI[3.09 to 22.00]. At the one-month follow-up, participants reported significantly higher positive affect in the intervention condition (M = 30.00, SD = 7.48) than the digital Shinrin-yoku condition (M = 15.45, SD = 11.21), $t(20) = 3.58$, $p = .002$, two tailed, 95% CI [6.07 to 23.02].

3.1.2 PANAS (negative affect).

There was no significant effect of time, $F(2, 38) = .98$, MSE= 11.05, $p = .38$, $\eta_p^2 = .05$, no significant effect of condition, $F(1, 19) = .39$, MSE= 36.72, $p = .54$, $\eta_p^2 = .02$, and no significant interaction, $F(2, 38) = 1.15$, MSE= 11.05, $p = .33$, $\eta_p^2 = .06$.

3.1.3. WEMWBS.

A significant effect was found for time, $F(2, 38) = .3.89$, MSE= 16.12, $p = .03$, $\eta_p^2 = .17$. However, Bonferroni corrected post hoc tests did not identify any significant differences between the time points. A significant main effect was found between the two conditions, $F(1, 19) = 5.67$, MSE= 91.87, $p = .03$, $\eta_p^2 = .23$. The level of reported

wellbeing for the Shinrin-yoku condition was greater (and therefore level of stress lower) (M = 52.99, SE = 1.69, 95% CI[49.46 to 56.53] than that for the digital Shinrin-yoku condition (M = 47.25, SE = 1.69, 95% CI[43.71 to 50.78], controlling for baseline. There was no significant interaction between condition and time, $F(2, 38) = .28$, MSE= 16.12, $p = .76$, $\eta_p^2 = .02$.

For descriptive purposes, effects of condition were tested per time point despite the non-significant interaction. At the two-week time point, wellbeing was higher in the Shinrin-yoku condition (M = 53.00, SD = 8.29) than in the digital Shinrin-yoku condition (M = 44.82, SD = 8.66), $t(20) = 2.26$, $p = .035$, two tailed, 95% CI[.64 to 15.72]. At the post intervention time point, wellbeing was higher in the Shinrin-yoku condition (M = 56.27, SD = 6.92) than in the digital Shinrin-yoku condition (M = 47.73, SD = 8.76; $t(20) = 2.54$, $p = .02$, two tailed, 95% CI[1.52 to 15.57]. At the one-month follow-up there was no significant difference between the Shinrin-yoku condition (M = 53.36, SD = -8.10) and digital Shinrin-yoku condition (M = 45.55, SD = 10.63), $t(20) = 1.94$, $p = .07$, two tailed, 95% CI[-.59 to 16.23].

3.2. Qualitative Analysis Results

Through the thematic analysis of the qualitative data from interviews (Appendix A), five overarching themes were identified in answer to the question, what is it about the experience of participating in Shinrin-yoku that is stress-reducing? (Table 2). Each of the five themes could be further broken down into 14 sub-themes. Within ‘Positive emotions’, ‘peace, quiet and calm’, ‘relaxing’ and ‘wellbeing’ were identified. Within “Environment’ two further codes were identified: ‘forest environment and winter climate’. “The senses’ was coded further into ‘touch/feel’, ‘sound’ and ‘sight’.

‘Refreshed mind-set’ identified three further codes: ‘clear head’, ‘focus’ and ‘time out’. Finally, the theme ‘enjoyable’ identified two further codes, ‘time went by quickly’ and ‘desire to continue’.

Additionally, the qualitative data gathered from the digital Shinrin-yoku group provide more support for being immersed rather than simply viewing nature (Table 3). Through thematic analysis, four overarching themes were identified in this group, which helps shed more light on why the actual Shinrin-yoku is effective due to better understanding the digital Shinrin-yoku group’s experience. The four themes could be further broken down into sub-themes. Within ‘positive emotions’, two further themes of ‘peace, calm’ and ‘relaxing’ were identified. ‘Negative emotions’ was broken down further into ‘unnerving’ and ‘sound’. Within ‘level of focus’, ‘short term impact’ and ‘loss of concentration’ were identified. And finally, within ‘level of enjoyment’, two further themes of ‘not enjoyable’ and ‘desire for real experience’ were identified.

4. Discussion

The aims of the current study were to compare, in a Western cultural setting, whether Shinrin-yoku or digitally simulated Shinrin-yoku differed in potential beneficial effect on mental health in terms of stress reduction, or an increase in positive affect or wellbeing. This study also looked to gain more insight into what it is about the experience of participating in Shinrin-yoku that is stress reducing. No effects of condition were found for measures of stress or negative affect. However, positive affect and wellbeing were higher in the Shinrin-yoku group. Although the findings are not unanimous across all of the measures, the current results are strengthened by the

consistent direction of effect across more than one measure (Podsakoff & Organ, 1986).

One particular finding of interest was the difference between the two conditions recorded at the one-month follow up, where there was a significantly higher positive affect for the Shinrin-yoku group compared to the digital Shinrin-yoku group. This is likely to be as a result of 73% of participants in the Shinrin-yoku condition continuing to practise Shinrin-yoku after the study sessions had finished, compared with only 18% in the digital Shinrin-yoku condition. Participants that continued to practice Shinrin-yoku, continued to receive benefits.

The thematic analysis also went some way to help unpick why a greater number of participants in the Shinrin-yoku condition continued to practice Shinrin-yoku despite the study ending. In the thematic analysis, five key themes emerged from the Shirin-yoku group: positive emotions, environment, the senses, refreshed mind-set and enjoyment. For the digital Shinrin-yoku condition the four key themes were: positive emotions, negative emotions, level of focus (loss of concentration) and level of enjoyment. As a whole, these findings also suggest that Shinrin-yoku is well tolerated by individuals in a Western society and can be implemented into daily life.

Taken together, the data obtained from both the interviews and questionnaires was complimentary and reinforced the power of actual Shinrin-yoku as opposed to digital Shinrin-yoku. These complimentary findings can be understood in terms of the Attention Restoration Theory, ART (Kaplan, 1995). ART posits that spending time in nature improves cognitive functioning and reduces attentional fatigue, as it reduces

the requirement for directed attention and will allow a person to rest and recover attentional capacity. Participants in the intervention group reported that their sessions allowed their "mind time to switch off" as well as "get away from the busyness of everyday life". Having a theme of a refreshed mind-set emerge supports ART well and suggests that the environment may have allowed participants the time to rest and recover their capacity for directed attention and ultimately increase their available cognitive resources, consequently reducing the stress experience.

Furthermore, when interpreted in parallel, the analyses combined helped to shed light on the underlying mechanisms. For example, immediately post experiment there was no difference between the two conditions. Through analysis of the interviews it can be seen that both conditions initially report positive emotions such as feelings of peace and calm as well as enjoyment for the study, which may help to explain there being no difference. However, measurements at the one-month follow up showed the Shinrin-yoku condition to improve wellbeing and positive affect significantly more than the digital Shinrin-yoku condition. Again, insights from the participants help to go some way to understanding this difference. Unlike the Shinrin-yoku condition, the digital Shinrin-yoku condition soon began to lose interest and express negative emotions such as how unnerving the study was. One significant difference between the two conditions that may provide an explanation of this, is that the Shinrin-yoku condition frequently mentioned the use of multiple senses in the experience, as well as their appreciation for this. Use of the senses may therefore be an important underlying mechanism as to why actual Shinrin-yoku as opposed to digital Shinrin-yoku can help improve wellbeing and may be worth further exploration.

We note a number of limitations of the current study. The main limitation is the relatively small sample size. Having a small sample size equates to lower statistical power which not only reduces the chance of detecting a true effect but also reduces the replicability of results (Button et al., 2013). Despite this limitation steps were taken by stratifying the sample by hand to ensure the data were as valid and reliable as possible. Results are in line with research with larger samples (Morita et al., 2007). The second limitation is that the conditions for the Shinrin-yoku and digital Shinrin-yoku group differed in multiple ways than purely exposure to nature. To overcome this, future work should aim to include a pure control condition as well. Another interesting condition for future research to explore would be Virtual Reality, which may bridge the gap between watching a video and being out in a nature environment (Maples-Keller, 2017). When thinking of issues which would prevent people from participating in Shinrin-yoku outside, a method of delivery which may help to close the gap and create similar lasting benefits to actual Shinrin-yoku is worth exploring. Finally, future research should look into the impact of different types of nature environments. The current study focused only on woodland/forest. However, existing research has shown other types of nature, such as savanna-like settings to also be stress-reducing, and the presence of water aiding even greater benefits (Frumkin, 2001; Barton & Pretty, 2010). It would be interesting to explore further how different types of nature environments effect stress reduction and perhaps adapting an intervention like Shinrin-yoku to different environments would provide more research evidence for the best nature environment to reduce stress.

5. Conclusion

The current results suggest Shinrin-yoku reduces stress and increases peoples positive affect and wellbeing more so than its digital counterpart. The study also provides evidence for Shinrin-yoku in Western culture, although we note that effects were not found on all measures. Moreover, the engagement of the five senses emerged as a strong theme and is an area worth future research aimed at understanding further the mechanisms behind Shinrin-yoku.

References

Aerts, R., Honnay, O., & Van Nieuwenhuyse, A. (2018). Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. British medical bulletin, 127(1), 5-22.Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. Environmental science & technology, 44(10), 3947-3955.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. Psychological science, 19(12), 1207-1212.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. Journal of environmental psychology, 25(3), 249-259.

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J. J., Hartig, T., Kahn, P. H., Jr., Kuo, M., Lawler, J. J., Levin, P. S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., Scarlett, L., Smith, J. R., van den Bosch, M., Wheeler, B. W., White, M. P., Zheng, H., Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. Science Advances, 5, eaax0903

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.

Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. Nature Reviews Neuroscience, 14(5), 365.

Chen, Y. (2017). The impact of biophilic design on health and wellbeing of residents through raising environmental awareness and nature connectedness (Doctoral dissertation, uga).

Cohen, S., Kamarck, T., & Mermelstein, R. (1994). Perceived stress scale. Measuring stress: A guide for health and social scientists.

Cox, D. T., Shanahan, D. F., Hudson, H. L., Plummer, K. E., Siriwardena, G. M., Fuller, R. A., ... & Gaston, K. J. (2017). Doses of neighborhood nature: the benefits for mental health of living with nature. *BioScience*, *67*(2), 147-155.

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. British journal of clinical psychology, 43(3), 245-265.

Creswell, J. W., & Clark, V. L. P. (2007, p.190). Designing and conducting mixed methods research.

DeVellis, R. F. (2012). Validity. Scale development: Theory and applications, 3.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

Feeling stressed (2017). Public Health England. Available at: https://www.nhs.uk/oneyou/stress#rjx4K7gio771QO1x.97

Frumkin, H. (2001). Beyond toxicity: human health and the natural environment. American journal of preventive medicine, 20(3), 234-240.

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H., Jr., Lawler, J. J., Levin, P. S., Tandon, P. S., Varanasi, U., Wolf, K. L., Wood, S. A. (2017). Nature contact and human health: A research agenda. Environmental Health Perspectives, 125(7), 075001-1. DOI:10.1289/EHP1663

Grinde, B., & Patil, G. G. (2009). Biophilia: does visual contact with nature impact on health and well-being?. International journal of environmental research and public health, 6(9), 2332-2343.

Hand, K. L., Freeman, C., Seddon, P. J., Recio, M. R., Stein, A., & van Heezik, Y. (2017). The importance of urban gardens in supporting children's biophilia. Proceedings of the National Academy of Sciences, 114(2), 274-279.

Hansen, M. M., Jones, R., & Tocchini, K. (2017). Shinrin-yoku (forest bathing) and nature therapy: A state-of-the-art review. *International journal of environmental research and public health*, *14*(8), 851.

Health and Safety Executive, (2019). Work-related stress, depression or anxiety statistics in Great Britain 2019. Available at: https://www.hse.gov.uk/statistics/dayslost.htm

Kahn Jr, P. H., Severson, R. L., & Ruckert, J. H. (2009). The human relation with nature and technological nature. *Current Directions in Psychological Science*, *18*(1), 37-42.

Kaplan, R., & Kaplan, S. (1989). The Experience of Nature: A Psychological Perspective. New York: Cambridge University Press.

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

Maples-Keller, J. L., Bunnell, B. E., Kim, S. J., & Rothbaum, B. O. (2017). The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. Harvard review of psychiatry, 25(3), 103-113.

Martyn, P., & Brymer, E. (2016). The relationship between nature relatedness and anxiety. Journal of health psychology, 21(7), 1436-1445.

Mayer, F. S., Frantz, C. M., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is nature beneficial? The role of connectedness to nature. Environment and behavior, 41(5), 607-643.

Meidenbauer, K. L., Stenfors, C. U., Young, J., Layden, E. A., Schertz, K. E., Kardan, O., ... & Berman, M. G. (2019). The gradual development of the preference for natural environments. *Journal of Environmental Psychology*, *65*, 101328.

Morita, E., Fukuda, S., Nagano, J., Hamajima, N., Yamamoto, H., Iwai, Y., ... & Shirakawa, T. (2007). Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. Public health, 121(1), 54-63.

Ochiai, H., Ikei, H., Song, C., Kobayashi, M., Takamatsu, A., Miura, T., ... & Miyazaki, Y. (2015). Physiological and psychological effects of forest therapy on middle-aged males with high-normal blood pressure. International journal of environmental research and public health, 12(3), 2532-2542.

Pallant, J. (2013, p.284-292). SPSS survival manual. McGraw-Hill Education (UK).

Park, B. J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., & Miyazaki, Y. (2010). The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. Environmental health and preventive medicine, 15(1), 18.

Podsakoff, P. M., & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. Journal of management, 12(4), 531-544.

Roberti, J. W., Harrington, L. N., & Storch, E. A. (2006). Further psychometric support for the 10-item version of the perceived stress scale. Journal of College Counseling, 9(2), 135-147.

Rogers, K. (2019). The Biophilia Hypothesis. Encyclopaedia Britannica. Available at: https://www.britannica.com/science/biophilia-hypothesis

Shinrin-yoku.org. Shinrin Yoku. [(accessed on 21 July 2017)]; Available online: http://www.shinrin-yoku.org/shinrin-yoku.html.

Soga, M., & Gaston, K. J. (2016). Extinction of experience: the loss of human–nature interactions. Frontiers in Ecology and the Environment, 14(2), 94-101.

Sonntag-Öström, E., Stenlund, T., Nordin, M., Lundell, Y., Ahlgren, C., Fjellman-Wiklund, A., ... & Dolling, A. (2015). “Nature's effect on my mind”–Patients’ qualitative experiences of a forest-based rehabilitation programme. Urban Forestry & Urban Greening, 14(3), 607-614.

Steptoe, A., & Feldman, P. J. (2001). Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems, and associations with socioeconomic status and health. Annals of Behavioral Medicine, 23(3), 177-185.

Sung, J., Woo, J. M., Kim, W., Lim, S. K., & Chung, E. J. (2012). The effect of cognitive behavior therapy-based “forest therapy” program on blood pressure, salivary cortisol level, and quality of life in elderly hypertensive patients. Clinical and Experimental Hypertension, 34(1), 1-7.

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., ... & Stewart-Brown, S. (2007). The Warwick-Edinburgh mental well-being scale (WEMWBS): development and UK validation. Health and Quality of life Outcomes, 5(1), 63.

Tsunetsugu, Y., Park, B. J., & Miyazaki, Y. (2010). Trends in research related to “Shinrin-yoku”(taking in the forest atmosphere or forest bathing) in Japan. Environmental health and preventive medicine, 15(1), 27.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. F. Wohlwill, Eds., Human Behavior and Environment. New York: Plenum Press, Vol. 6, Behavior and the Natural Environment,

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. Journal of environmental psychology, 11(3), 201-230.

Understanding the stress response (2016). Harvard Health Publishing. Available at: https://www.health.harvard.edu/staying-healthy/understanding-the-stress-response

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

Figure 1. Shinrin-yoku site where the intervention condition went to participate in Shinrin-yoku, for four hourly sessions.

Figure 2. Still from the video shown to control participants from the hour-long video session they took part in once a week for four consecutive weeks

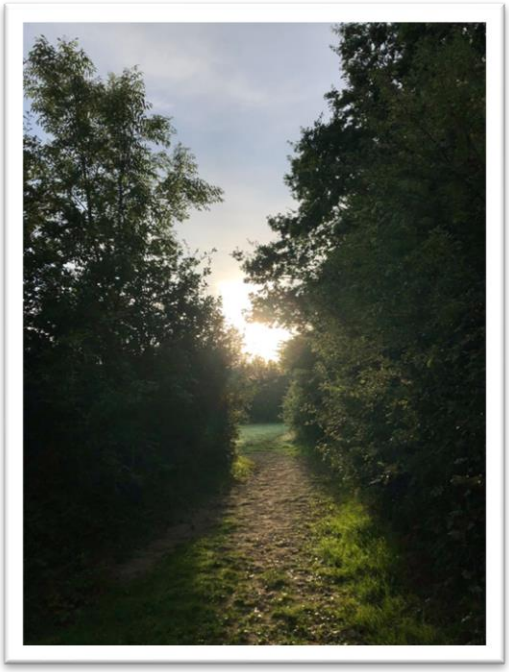

Table 1.
Stratification results

	Intervention	Control
Age	Range = 20-65 years (M = 40.27, SD = 17.27)	Range = 19-54 years (M = 31.73, SD = 13.02)
Gender	(Males = 2; Females = 9)	(Males = 2; Females = 9)
Occupation	(Student = 5; Employed = 6)	(Student = 5; Employed = 6)

Table 2.
Thematic Analysis Results Table – how does the experience of Shinrin-yoku reduce stress?

Theme	Coding	Extract from Interviews
Positive emotions	Peace, quiet and calm	"surprisingly peaceful" "Being in the fresh air has been so peaceful" "calming and refreshing" "I also enjoyed not talking!" "the peace and quiet is so needed"
	Relaxing	"the sounds from the birds singing made me feel relaxed" "it helped me relax" "I felt more relaxed with each session"
	Wellbeing	"I genuinely feel lighter within myself" "good time to unwind and relax from daily stressors" "I have decided to make it part of my weekly routine…to de-stress"
Environment	Forest environment	"I find the trees very calming also, almost like being in a cocoon" "I really liked the refreshing feeling the forest gives off"
	Winter climate	"sometimes it felt too chilly to be out there in the woods" "I think the whole experience could have been very different if the weather had been awful"
The senses	Touch/feel	"It has made me feel fresh" "I feel fresher inside" "I even enjoyed touching the trees, feeling the dew on the leaves"
	Sound	"Letting the sounds come in and out" "Sounds of the birds singing" "Rustle of the trees" "I really enjoyed the time out…and all the sounds of nature"
	Sight	"…scenery was lovely" "…squirrels scampering among the leaves on the ground, birds on low bushes" "I saw so much wildlife and the ponds, lakes and woodland was so beautiful"
Refreshed mind-set	Clear head	"it is nice just to have a clear head" "I found my thoughts dissipate with each footstep"

	Focus	"Focusing my mind in the moment" "the woods are so still it seems to still you also" "it gave me time to think"
	Time out	"I really needed this time for myself" "It was nice to get away from the busyness of everyday life" "It gave me time each week to do nothing but simply enjoy my surroundings and almost give my mind time to switch off"
Enjoyable	Time went by quickly	"I also found the time go by really fast…too fast!" "it goes quicker every time"
	Desire to continue	"I really enjoyed being in nature and breathing in the fresh air" "I really looked forward to the sessions"

Table 3. Thematic Analysis Results Table – immersion vs. nature; experience of the control group

Theme	Coding	Extract from interviews
Positive emotions	Peace, calm	"the crunch of the leaves and the birdsong it genuinely felt calming to me" "made me feel really peaceful"
	Relaxing	"was quite relaxing to watch" "very relaxing"
Negative emotions	Unnerving	"it was sort of creepy and a bit scary!" "throughout…I was expecting something to happen. Like in the movies where someone will jump out from the bushes or there will be a dead body found"
	Sound	"the walking noise…was highly irritating throughout" "no one was talking"
Level of focus	Short term impact	"relaxed me for a while" "after each week…lost some of its original relaxation" "lost concentration a bit just sitting there watching it"
	Loss of concentration	"lots going through my mind whilst watching it" "im not very good at concentrating on things like that for very long" "lost concentration"
Level of enjoyment	Not enjoyable	"not always engaging" "boring" "it was boring and a bit irritating"
	Desire for real experience	"I do not feel this experience was beneficial to me because I was not actually experiencing it in real life" "I would have preferred the experience to have been done outside as I think it would give better results"