No Effect of Nature Representations on State Anxiety, Actual and Perceived Noise

---

Max Korbmacher^{1*}, Lynn Wright²

1 University of Bergen, Faculty of Psychology, Department of Biological and Medical Psychology; Nattland Studentbyen 110, 5010, Bergen, Norway; +47 45844066; max.korbmacher@gmail.com

2 Abertay University, School of Applied Sciences, Division of Psychology; Bell St, Dundee DD1 1HG, United Kingdom; +44 1382 308332; l.wright@abertay.ac.uk

*Corresponding author

This work was supported by the Bernard King Library, Dundee, UK with the posters required for the research.

Pre-registration: <http://aspredicted.org/blind.php?x=bg7jp3>

Replication documentation (data, code and supplementary materials): <https://osf.io/5xbs6/>

Abstract

Previous research indicates that nature and nature representations might have positive effects and noise negative effects on various facets of life, such as performance, perceived life quality, physical and mental health. In this intervention, we observed whether posters showing forests can be used to reduce actual noise, perceived noise, and state anxiety in university library users. Measurements were taken twice daily for a 5-day period pre-intervention and again during the intervention, when posters were installed. No significant differences were found perceived or actual noise levels and state anxiety between pre-intervention and intervention phase. Correlations between actual and perceived noise, and actual noise and state anxiety were inconclusive. Finally, regression models with actual and perceived (overall and talking) noise and study phase as predictors delivered mixed results only explaining a small portion of the variance of state anxiety. The absence of an observed effect of nature representations on state anxiety, as well as actual and perceived noise is discussed.

Key words: nature representations, posters, library, noise, state anxiety

Introduction

Noise can act as a stressor impacting various facets of life, such as health (e.g., in preschool employees, see Sjödin et al., 2012), satisfaction and perceived life quality (Leather, et al., 2003), as well as performance (Errett et al., 2006). A large body of research examined effects of noise on health with the congruent conclusion of possible different negative health outcomes high noise levels, such as increased blood pressure, pulse and stress hormone levels – especially when exposed to higher noise levels over longer periods of time (e.g., Babisch, 2002; Evans et al., 2001; Schmidt et al., 2013; Van Kempen et al., 2002). Noise is a commonly used stressors in animal models, impairing animals' health (Rasmussen et al., 2009) and behaviour (Shannon et al., 2016). For example, Arnsten and Goldman-Rakic (1998) showed that continuous loud noise impaired rhesus monkeys' prefrontal cortical cognitive functioning.

Noise exposure can also moderated adrenaline levels and impair endothelial function in healthy adults during sleep (Schmidt et al., 2013). Further consequences of sleep-time noise exposure were decreased sleep quality and increased cardiovascular adverse events (Schmidt et al., 2013). A meta-analysis by Van Kempen and colleagues (2002) observing the relationship between noise exposure and blood pressure in individuals with ischemic heart disease could show a positive relationship between occupational and air traffic noise exposure and blood pressure. Evans et al. (2001) found elevated resting pulse and cortisol levels in children living in noisier areas compared to children living in quieter areas. Furthermore, children living next to a major airport had higher depressed quality of life scores, stress levels and resting blood pressure after completion of the construction works of the airport (Evans et al., 1998).

Besides physiological consequences, also life quality can be altered by prolonged noise exposure. For example, noise levels can moderate the impact of psychosocial stress in the

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

workplace on job satisfaction and well-being (Leather et al., 2003). Additionally, acute stress caused by noise impairs cognitive control by the anterior cingulate cortex (Banis & Lorist, 2012). Accordingly, lower performance may be another negative consequence of the exposure to higher noise levels, which seems to specifically apply when individuals' perception of elevated noise levels is negative (Errett et al., 2006).

Looking influences of noise in educational contexts, Klatte and colleagues (2013) found in a literature review on noise effects on children's cognitive performance that indoor noise led to lower verbal performance and chronic noise exposure to lower reading ability. University libraries are areas for learning, usually with implemented rules demanding silence. Specifically, when the expectation of silence is broken the ability to focus can be disrupted. This has been shown in office workers having problems to focus due to background noise (Banbury & Berr, 2005), or in the general public due to road traffic noise, respectively (Björk et al., 2006). Similarly, Norlander and colleagues (2005) showed that pupils could focus better when noise levels were reduced, but their stress levels remained unchanged.

According to some of the most influential theories of restorative environments, such as *Attention Restoration Theory* (Kaplan, 1995), *Stress Recovery Theory* (Ulrich, 1991), and *Perceptual Fluency Account* (see Steg et al., 2012), there are various positive effects of nature and nature representations on cognitive performance, stress reduction and health. For example, Raanaas et al. (2011) showed that nature representation could improve participants' attention capacity. Moreover, several studies reported a positive effect of green spaces on health in populations living in urban areas (Brown et al., 2016; Cohen-Cline et al., 2015; Dimitrova & Dzhambov, 2017), which is, according to Dzhambov et al. (2018a), mediated, for instance, by social cohesion and physical activity. One important aspect to consider when looking at health

benefits of green areas is noise, as green spaces seem to alter adverse health effects of noise (Dzhambov et al., 2018b; Gidlöf-Gunnarsson & Öhrström, 2007). In this context, Gidlöf-Gunnarsson and Öhrström (2007) observed citizens living in a high-noise urban area and demonstrated that access to green areas was important to improve well-being and reduce stress-related mental health problem prevalence. Moreover, a relationship between the number of greenspaces and the effect of road traffic noise on students' mental health has been suggested (Dzhambov et al., 2018b).

Interactions between physical environmental features and psychosocial outcomes can also be expected at the workplace (Leather et al., 2003). And the relationships between nature and reduced stress might be transferrable to nature representations, for example, installed at a workplace or library (Ulrich, 1991). Hence, it can be hypothesised that nature elements or representations influence stress and noise in a university library setting. Moreover, nature representations might be a cost-efficient and sustainable way of improving mental, and hence creating healthier learning and working environments. Although there is a growing body of research examining the effects of nature representations on stress levels and adverse effects of noise separately, no study has yet examined how state anxiety levels, perceived and actual noise level are influenced by nature representations in one single study. Therefore, the research question in the current study is: “*Are nature representations an effective intervention to lower state anxiety, as well as actual and perceived noise?*”

Accordingly, *state anxiety*, *perceived noise*, and *actual noise* were observed, as it was hypothesised that nature representations influence state anxiety (H_1), nature representations influence perceived noise levels (H_2), nature representations influence actual noise levels (H_3),

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

there is a relationship between actual and perceived noise (H_4), and there is a relationship between (actual and perceived) noise and state anxiety (H_5).

Method

Participants

A total of $N=229$ participants, mainly students, were recruited; $n=125$ in the pre-intervention period and $n=104$ in the intervention period. The university's ethics committee approved the study. Data were collected in accordance with institutional GDPR data storage rules (data were collected, digitalised, anonymised and safely stored), after participants were provided with information and gave their consent to participate. As an incentive, participants could enter a lottery to win one of two £10 Amazon vouchers in each of the two study phases. A printed debrief was provided after each participation.

Instruments and Measures

State anxiety was measured with the help of self-reports on Spielberger and colleagues' (1983) 20-item 4-point Likert-like State Anxiety Inventory (Cronbach's $\alpha=.92$; pre-intervention $\alpha=.93^1$, intervention $\alpha=.91$ for original and imputed data sets) with questions such as "I feel calm" or "I am worried" resulting in one mean score with the items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20 being reversed. *Perceived noise levels* were measured with a series of questions based on the question "How noisy would you rate the sound emitted by different sources in the library?", particularly asking for overall noise and people talking. Finally, some explorative open-ended questions were used to control for the time spent in the library, the activity the library was used for, date of upcoming exams/deadlines and in the intervention phase an additional question on

---

¹ In two of the ten imputed datasets Cronbach's $\alpha=.92$ for phase 1, in eight of ten $\alpha=.92$.

whether the nature representations were noticed. *Actual noise levels* were measured in dB, collected with a Tacklife SLM01 Noise Decibel Meter. Three different images of forests complying with the local fauna were selected (figure 1) as the nature representations stimuli. Those should include most naturalness, to maximise the effect of perceived restorativeness (see Carrus et al., 2013).

Figure 1

Stimuli Images used for the Posters

Design

This in vivo intervention study had a between-groups design containing a pre-intervention and an intervention phase. In both phases actual and perceived noise as well as state anxiety were assessed twice a day over a period of 5 consecutive weekdays (Monday to Friday). Subjects' reported noise and state anxiety levels were measured to be compared between conditions and correlated, and (perceived and actual) noise used to explain state anxiety. Hypotheses, methods and statistical analyses were pre-registered, followed by data collection and analysis. No power analyses were conducted as the goal was to include as many participants as possible during a pre-defined time of 5 working days each phase. However, a sensitivity analysis conducted with the pwr package (Champely et al., 2020) in R (v3.6.3; R Core Team, 2020) suggests that with $\alpha=.05$, $\beta=.80$ (or 80% power) and group sample sizes $n_1=125$ and $n_2=104$, a minimal effect of $d=.37$ can be observed when comparing groups. For two-sided correlations,

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

assuming the same α - and β -level, smallest observable correlation coefficient for both phases together is $r=.18$, $r=.25$ for phase 1 only, and $r=.27$ for phase 2 only. The maximum detectable effect size using linear regression is $f^2= 0.035$, when calculating with the same α - and β -level, numerator=1 and denominator=227, but $f^2= .064$ for phase 1 and $f^2=.077$ for phase 2 only.

Procedures

In the first part of the study, actual noise levels were measured at 2 different central locations on each of the four library floors (figure 2) at 2 points of time for 5 consecutive weekdays, at 12pm and 2pm. Afterwards, library visitors leaving the library were asked at the library exit to fill in the questionnaire on perceived noise and state anxiety (state anxiety) for one hour at each session during the busiest hours (12-1pm and 2-3pm). The questionnaires were presented in printed form and completed with pen or pencil.

Figure 2

Locations of Posters and Measurements on the Library's Four Levels

Note: x = poster location; o = actual noise (dB) measurement location

For the second phase, the three nature representations (figure 1) were printed 4 times each on A1 sized posters (equalling 12 posters) and distributed in random order on the 4 floors of the library. On each of the floors, 3 differing posters were placed at the same locations on the main travelling routes on levels 2-4. Due to the differing architecture of level 1, the position of the posters differed slightly (figure 2). The procedure in the intervention phase resembled the phase 1 procedure. The study was conducted in the beginning of the academic semester and there was a 1-week break between pre-intervention and intervention phases.

Results

Analyses were executed as stated in the preregistration. As only 14 subjects repeatedly participated in the study no repeated measures test could be used. Due to missing data in the state anxiety inventory, 10 datasets were imputed i) 5 based on the 20 items and ii) 5 based on the 20 items and their mean scores, resulting in 11 datasets which were used in analyses involving state anxiety.

TABLE 1

Perceived Noise, Actual Noise and State Anxiety in the Original Data by Phase

	Pre-Intervention		Intervention	
	M	SD	M	SD
Overall Noise	2.89	1.06	3.14	1.09
Noise from People Talking	3.26	1.34	3.46	1.12
Actual Noise (in dB)	49.04	8.04	49.41	7.07
State Anxiety	1.89	.53	1.84	.52

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

Due to the non-normality of the self-report data, Mann-Whitney tests were used, revealing no differences in perceived overall noise levels ($p=.117$), people talking ($p=.171$), or state anxiety ($.658 > p > .308$), and actual noise levels ($p=.643$) between pre-intervention and intervention phase, concluding in the rejection of H_1 - H_3 .

To make sure that variations in anxiety and noise level were not driven by time of measurement or floor/level of the library, first, a Mann-Whitney-U tests were conducted showing no difference between perceived overall noise ($p=.529$), noise from people talking ($p=.246$), state anxiety ($.992 > p > .831$) or actual noise levels for measurements taken between 12-1pm and 2-3pm ($p=.927$). Second, a Welch's one-way test was conducted showing significant differences in noise levels between the 4 library levels [$H(3)=103.11$, $p<.0001$]. Mann-Whitney post-hoc comparisons revealed significant differences in noise between all library levels, with only the difference between the first two floors being non-significant ($p=.074$; see table 2).

TABLE 2

Pairwise Comparison of Noise Levels Across floors

	Noise Level in dB		Mean Differences			
	M	SD	Level 1	Level 2	Level 3	Level 4
Level 1	56.0	4.24	0			
Level 2	53.9	5.10	2.09	0		
Level 3	44.8	5.13	11.16***	9.07***	0	
Level 4	42.3	4.87	13.69***	11.59***	2.52**	0

* $p<.05$, ** $p<.01$, *** $p<.001$

Looking at the relationships between actual and perceived noise, Spearman's correlations between state anxiety and perceived overall noise ranged from $r_s(227)=.133$, $p=.045$ to

$r_s(227)=.160$, $p=.015$, and between state anxiety and talking noise from $r_s(227)=.142$, $p=.032$ to $r_s(227)=.163$, $p=.014$), all significant at an α -level=.05. When differentiating by study phase, none of the pre-intervention correlations between state anxiety and perceived overall noise were significant ($.208 > p > .161$) but most post-intervention correlations were ($.208 > r_s(227) > .169$, $.086 > p > .032$), with the exception of 3 in the imputed datasets. Correlations between state anxiety and noise from people talking were non-significant pre-intervention ($.151 > r_s(227) > .136$, $.166 > p > .048$) and during intervention ($.189 > r_s(227) > .136$, $.166 > p > .048$; with the exception of one imputed dataset). And correlations between state anxiety and actual noise were non-significant for all data ($.642 > p > .456$), pre-intervention ($.860 > p > .758$), and during the intervention phase ($.717 > p > .449$).

Correlations between perceived overall noise and actual noise were significant for all data ($r_s(227)=.142$, $p=.032$), not for phase 1 data only ($p=.415$), but phase 2 data ($r_s(227)=.227$, $p=.021$). Correlations between perceived noise from people talking and actual noise were non-significant for all data ($p=.284$), pre-intervention ($p=.919$) and intervention phases ($p=.157$). Hence the evidence for H_4 is inconclusive. Exploratory correlations between state anxiety and time spent in the library were non-significant for all data ($.999 > p > .784$), and both pre-intervention ($.795 > p > .726$) and during intervention ($.957 > p > .4798$).

Furthermore, hierarchical linear regressions were run with i) perceived (overall and talking) noise as predictors of state anxiety levels [$F(2, 226)=2.78$, $p=.064$, $R^2=.015$], ii) adding actual noise to the model [$F(2, 226) = 2.78$, $p=.064$, $R^2_{adj} = .015$], and iii) when adding phase to the model [$F(2, 226)=2.89$, $p=.036$, $R^2_{adj}=.024$], overall noise perception was a significant predictor of state anxiety $b=.286$, $t(224)=1.975$, $p=.0495$. While model 3 was significant, when running an ANOVA, none of the three models differed significantly from each other ($p=.0815$).

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

Considering mixed evidence from the different models and low model fit, the evidence for H_5 is inconclusive.

Discussion

No significant differences of perceived and actual noise levels as well as state anxiety could be revealed between the pre-intervention phase and the intervention phase. Small correlations were detected between state anxiety and perceived (talking and overall) noise, but when differentiating those between pre-intervention and intervention only the small intervention phase correlation between state anxiety and perceived overall noise fell below $\alpha=.05$. Correlations between state anxiety and actual noise were non-significant. Actual noise was correlated with overall perceived noise during the intervention phase and both phases together but not pre-intervention. Actual noise was not correlated with perceived noise coming from people talking. The relationship between actual and perceived noise remains hence inconclusive. Finally, a model with actual and perceived noise levels and phase of study could explain a small portion of the overall variance of state anxiety. However, due to low model fit and non-significance of similar regression models without (pre-/intervention) phase as included predictor, results are inconclusive.

Other studies have consistently reported positive effects of nature or nature representations, for example, on health (Brown et al., 2016; Cohen-Cline et al., 2015; Dimitrova & Dzhambov, 2017) or to avoid negative health consequences of noise (Dzhambov et al., 2018b; Gidlöf-Gunnarsson & Öhrström, 2007). However, the presented results suggest that these positive effects of nature representations do not apply to state anxiety, noise perception or actual noise. Although there might be variations among different populations and students of different programs and year of study, a recent study (Korbmacher & Wright, 2020) did not reveal

differences in perceived stress across the dissertation year, which is strongly correlated to state anxiety (e.g., Petrac et al., 2009). This advises that the presented evidence for the null hypothesis (no effect of nature representations on state anxiety) is not due to fluctuations of anxiety levels.

There are a variety of arguments serving to explain why placing nature representations in the library did not affect state anxiety and noise levels. *Firstly*, noise levels might generally have been too low to influence state anxiety ratings; and background noise might become a habituated stimulus after a short time (Banburry & Berry, 1997). As presented in table 2, noise levels differed significantly on the different library levels. Students might hence have chosen a place to sit with an acceptable noise level. Additionally, state anxiety and perceived overall noise as well as actual and perceived overall noise levels were only correlated in the intervention phase, which might be due to an awareness-creating effect of the posters or biased participants, for instance, through the ‘good subject effect’ (see Nichols & Maner, 2008).

Secondly, there are differences between nature representations and nature. For example, Dzhambov et al. (2018a), describes a variety of mediators in the relationship between green spaces and health, such as social cohesion and physical activity. These moderators are not given in the same way when just providing posters as nature representations instead of usable spaces. Moreover, according to the attention restoration theory (Kaplan, 1995), green spaces have a greater restorative potential when individuals are placed in them compared to being placed in built environments including only few nature representations. Kaplan describes that more features need to be cognitively processed in built environments. However, differences in mediators for health outcomes between nature/green spaces and nature representations still require further research.

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

Thirdly, the posters' characteristics might contribute to not detecting true effects by influencing or even disallowing the posters' perception. For example, the posters' positioning, size, colours and contents are influencing whether posters were perceived and processed. Moreover, attention to the posters might be required to cause effects, which is otherwise focused on the built environment which does not have the same restoring and 'stress reducing' effects as nature or nature representations (Kaplan, 1995; Ulrich, 1991). A1 posters might not be a cue strong enough to influence state anxiety and noise levels in a library as they do not catch the attention sufficiently. Although still in need of refinement, different measures of health outcomes by the amount of green space indicate that more green spaces lead to better health in the area (Rugel et al., 2017). The ratio of posters/m² seems hence influential and might have been underestimated. The posters were placed at the main walking routes in the library. However, a more thoroughly analysis of the library users' walking patterns and gaze directions could have provided clearer directions of where to place the posters. Hence, the posters' size, colours, contents and position might be altered in order to be (more) notable. How to optimize these parameters to maximize attention to the posters requires further investigation.

The significance of correlations between perceived (overall and talking) noise and actual noise was mixed and therefore inconclusive. However, nature representations themselves or nature representations embedded in the library/study context including a researcher asking for participation at the front door of the library might support an increased awareness of noise (e.g., Nichols & Maner, 2008). Although only 14 subjects participated repeatedly, it might be that a greater number of participants was primed due to the presence of the researcher in the library during the pre-intervention phase, leading to a generally greater stimuli-awareness. Moreover, although different from zero, the significant correlation coefficients for actual and perceived noise

but also actual noise and state anxiety were only small, including the possibility of them being false positives.

Furthermore, in the regression models actual and perceived noise were poor predictors of state anxiety. This finding counteracts previous research showing that noise increases state anxiety levels (Standing et al., 1990; Standing & Stace, 1980). However, participants in these studies were exposed to white noise louder than 61dB, whereas noise levels in this study were on average approximately 50dB, consisting of background noise of different frequencies (in both phases, see table 1). Hence, the noise was not only differing in volume but also frequency range. Although no clear threshold could be identified at which physiological, for example, cardiovascular adverse effects of noise appear, there are some studies showing adverse health effects caused by noise levels around 50dB, with however a higher number of studies making use of paradigms using noise levels higher than 50dB (van Kempen et al., 2002).

Moreover, also noise perception and therefore a higher noise sensitivity are influential as they might increase state anxiety levels (Park et al., 2017) and decrease attention (Tristan-Hernández et al., 2017), productivity (Meegahapola & Prabodanie, 2018) as well as performance (Errett et al., 2006). Yet, noise perception seems to be influenced by a range of variables such as current mood (Västfjäll, 2002). Hence, it is necessary to include more variables than just actual and perceived noise levels in a model used to predict state anxiety as a function of noise, such as mood and noise-sensitivity measures.

Conclusion

Against the trend of studies showing positive effects of nature representations on mental health, we could not find any differences in state anxiety after implementing nature posters as intervention in a university library. We tested a new approach of using nature representations to

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

reduce actual and perceived noise levels, with the data not supporting the approach to cause changes. Although it could not be shown in this study that an intervention with posters as the choice of nature representations impacted noise levels or state anxiety, other methodologies might lead to such effects, for example, when conducting studies with similar or other nature representations and settings in controlled environments. Assuming low effect sizes for such intervention, their practical significance might however be low in library settings. A long list of factors such as the loudness, volume, frequency spectrum, the nature representations' perception, awareness, features and location, as well as the surrounding the nature representations are embedded in or sample characteristics such as age, gender, or profession might be influential variables which require further investigation. Hence, further research is needed to widen the understanding of the impact of nature representations on state anxiety as well as perceived and actual noise in different context and populations, and their usability in practical contexts.

References

- Arnsten, A. F., & Goldman-Rakic, P. S. (1998). Noise stress impairs prefrontal cortical cognitive function in monkeys: evidence for a hyperdopaminergic mechanism. *Archives of General Psychiatry*, 55(4), 362-368. doi:10.1001/archpsyc.55.4.362
- Babisch, W. (2002). The noise/stress concept, risk assessment and research needs. *Noise and Health*, 4(16), 1.
- Banbury, S. P., & Berry, D. C. (2005). Office noise and employee concentration: Identifying causes of disruption and potential improvements. *Ergonomics*, 48(1), 25-37. doi:10.1080/00140130412331311390
- Banbury, S. P., & Berry, D. C. (1997). Put-Up Or Shut-Up? Habituation to Speech and Office Noise. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 41, No. 1, pp. 514-518). Sage CA: Los Angeles, CA: SAGE Publications.
- Banis, S., & Lorist, M. (2012). Acute noise stress impairs feedback processing. *Biological Psychology*, 91(2), 163-171. doi: 10.1016/j.biopsycho.2012.06.009
- Björk, J., Ardö, J., Stroh, E., Lövkvist, H., Östergren, P.-O., & Albin, M. (2006). Road traffic noise in southern Sweden and its relation to annoyance, disturbance of daily activities and health. *Scandinavian journal of work, environment & health*, 392-401.
- Brown, S. C., Lombard, J., Wang, K., Byrne, M. M., Toro, M., Plater-Zyberk, E., . . . Perez-Gomez, G. (2016). Neighborhood greenness and chronic health conditions in Medicare beneficiaries. *American journal of preventive medicine*, 51(1), 78-89. doi: /10.1016/j.amepre.2016.02.008
- Carrus, G., Laforteza, R., Colangelo, G., Dentamaro, I., Scopelliti, M., & Sanesi, G. (2013). Relations between naturalness and perceived restorativeness of different urban green spaces. *Psychology*, 4(3), 227-244. doi: 10.1174/217119713807749869
- Champely, S., Ekstrom, C., Dalgaard, P., Gill, J., Weibelzahl, S., Anandkumar, A., Ford, C., Volcic, R., & De Rosario, H. (2017). pwr: Basic functions for power analysis [Software Package]. URL: <https://CRAN.R-project.org/package=pwr>
- Cohen-Cline, H., Turkheimer, E., & Duncan, G. E. (2015). Access to green space, physical activity and mental health: a twin study. *J Epidemiol Community Health*, 69(6), 523-529. doi: 10.1136/jech-2014-204667
- Dimitrova, D. D., & Dzhambov, A. M. (2017). Perceived access to recreational/green areas as an effect modifier of the relationship between health and neighbourhood noise/air quality: Results from the 3rd European Quality of Life Survey (EQLS, 2011–2012). *Urban Forestry & Urban Greening*, 23, 54-60. doi:10.1016/j.ufug.2017.02.012
- Dzhambov, A., Hartig, T., Markevych, I., Tilov, B., & Dimitrova, D. (2018a). Urban residential greenspace and mental health in youth: different approaches to testing multiple pathways yield different conclusions. *Environmental research*, 160, 47-59. doi: 10.1016/j.envres.2017.09.015
- Dzhambov, A. M., Markevych, I., Tilov, B. G., & Dimitrova, D. D. (2018b). Residential greenspace might modify the effect of road traffic noise exposure on general mental health in students. *Urban Forestry & Urban Greening*, 34, 233-239. doi: /10.1016/j.ufug.2018.06.022
- Errett, J., Bowden, E. E., Choiniere, M., & Wang, L. M. (2006). Effects of noise on productivity: does performance decrease over time? *Building Integration Solutions* (pp. 1-8).
- Evans, G. W., Bullinger, M., & Hygge, S. (1998). Chronic Noise Exposure and Physiological Response: A Prospective Study of Children Living Under Environmental Stress. *Psychological Science*, 9(1), 75-77. doi:10.1111/1467-9280.00014
- Evans, G. W., Lercher, P., Meis, M., Ising, H., & Kofler, W. W. (2001). Community noise exposure and stress in children. *The Journal of the Acoustical Society of America*, 109(3), 1023-1027. doi: 10.1121/1.1340642
- Gidlöf-Gunnarsson, A., & Öhrström, E. (2007). Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. *Landscape and urban planning*, 83(2), 115-126. doi:10.1016/j.landurbplan.2007.03.003
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169-182.
- Klatte, M., Bergström, K., & Lachmann, T. (2013). Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology*, 4, 578. doi:10.3389/fpsyg.2013.00578
- Korbmacher M., & Wright, L. (2020). What can we learn from Exploring Cognitive Appraisal, Coping Styles and Perceived Stress in UK Undergraduate Dissertation Students? *Psychology Teaching Review*, 26(1).

Nature Representations to Reduce Noise, Noise Perception, and State Anxiety?

- Lakens, D. (2017). Equivalence Tests: A Practical Primer for t Tests, Correlations, and Meta-Analyses. *Social Psychological and Personality Science*, 8(4), 355–362. <https://doi.org/10.1177/1948550617697177>
- Leather, P., Beale, D., & Sullivan, L. (2003). Noise, psychosocial stress and their interaction in the workplace. *Journal of Environmental Psychology*, 23(2), 213–222. doi:10.1016/S0272-4944(02)00082-8
- Meegahapola, P. A., & Prabodanie, R. R. (2018). Impact of environmental conditions on workers' productivity and health. *International Journal of Workplace Health Management*, 11(2), 74–84. doi:10.1108/IJWHM-10-2017-0082
- Nichols, A. L., & Maner, J. K. (2008). The good-subject effect: Investigating participant demand characteristics. *The Journal of general psychology*, 135(2), 151–166.
- Norlander, T., Moås, L., & Archer, T. (2005). Noise and stress in primary and secondary school children: noise reduction and increased concentration ability through a short but regular exercise and relaxation program. *School Effectiveness and School Improvement*, 16(1), 91–99. doi:10.1080/092434505000114173
- Park, J., Chung, S., Lee, J., Sung, J. H., Cho, S. W., & Sim, C. S. (2017). Noise sensitivity, rather than noise level, predicts the non-auditory effects of noise in community samples: a population-based survey. *BMC public health*, 17(1), 315. doi:10.1186/s12889-017-4244-5
- Raanaas, R. K., Evensen, K. H., Rich, D., Sjøstrøm, G., & Patil, G. (2011). Benefits of indoor plants on attention capacity in an office setting. *Journal of Environmental Psychology*, 31(1), 99–105. doi:<http://dx.doi.org/10.1016/j.jenvp.2010.11.005>
- Rasmussen, S., Glickman, G., Norinsky, R., Quimby, F. W., & Tolwani, R. J. (2009). Construction noise decreases reproductive efficiency in mice. *Journal of the American association for laboratory animal science*, 48(4), 363–370.
- R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: <https://www.R-project.org/>.
- Rugel, E. J., Henderson, S. B., Carpiano, R. M., & Brauer, M. (2017). Beyond the Normalized Difference Vegetation Index (NDVI): developing a natural space index for population-level health research. *Environmental research*, 159, 474–483. doi:10.1016/j.envres.2017.08.033
- Schmidt, F. P., Basner, M., Kröger, G., Weck, S., Schnorbus, B., Muttray, A., . . . Warnholtz, A. (2013). Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults. *European heart journal*, 34(45), 3508–3514. doi:10.1093/eurheartj/eh269
- Shannon, G., McKenna, M. F., Angeloni, L. M., Crooks, K. R., Frisrup, K. M., Brown, E., . . . Briggs, J. (2016). A synthesis of two decades of research documenting the effects of noise on wildlife. *Biological Reviews*, 91(4), 982–1005. doi:10.1111/brv.12207
- Sjödin, F., Kjellberg, A., Knutsson, A., Landström, U., & Lindberg, L. (2012). Noise and stress effects on preschool personnel. *Noise and Health*, 14(59), 166–178. doi:10.4103/1463-1741.99892
- Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P., & Jacobs, G. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.
- Standing, L., Lynn, D., & Moxness, K. (1990). Effects of noise upon introverts and extroverts. *Bulletin of the Psychonomic Society*, 28(2), 138–140. doi:10.3758/BF03333987
- Standing, L., & Stace, G. (1980). The effects of environmental noise on anxiety level. *The Journal of general psychology*, 103(2), 263–272.
- Steg, L., van den Berg, A. E., & De Groot, J. I. (2012). *Environmental psychology: An introduction*. John Wiley & Sons.
- Tristan-Hernández, E., Pavón-García, I., Campos-Cantón, I., Ontaño´n-García, L., & Kolosovas-Machuca, E. (2017). Influence of Background Noise Produced in University Facilities on the Brain Waves Associated With Attention of Students and Employees. *Perception*, 46(9), 1105–1117. doi:10.1177/0301006617700672
- Ulrich, R. S. (1991). Effects of interior design on wellness: Theory and recent scientific research. *Journal of health care interior design*, 3(1), 97–109.
- Van Kempen, E. E., Kruize, H., Boshuizen, H. C., Ameling, C. B., Staatsen, B. A., & de Hollander, A. E. (2002). The association between noise exposure and blood pressure and ischemic heart disease: a meta-analysis. *Environmental health perspectives*, 110(3), 307. doi:10.1289/ehp.02110307
- Västfjäll, D. (2002). Influences of Current Mood and Noise Sensitivity on Judgments of Noise Annoyance. *The Journal of Psychology*, 136(4), 357–370. doi:10.1080/00223980209604163