

The Effects of White, Pink, and Violet Noise on Blood Pressure and Heart Rate in Healthy Office Workers: An Experimental Study

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ABSTRACT

Background: Prolonged exposure to work-related stressors in office environments can elevate physiological indicators such as blood pressure and heart rate. While music has been shown to reduce stress, it may interfere with cognitive performance. Colored noises—such as white, pink, and violet—are emerging as potential alternatives for promoting relaxation without compromising concentration. This study aimed to evaluate the effects of exposure to three types of colored noise (white, pink, and violet) on systolic and diastolic blood pressure and heart rate among healthy office workers.

Methods: This experimental research was conducted in 2024 on 43 office employees without a history of cardiovascular disease to evaluate the effects of 4 colored noises on blood pressure and heart rate. Participants were exposed to each noise type at 65 dB for 30 minutes on separate days. Baseline and post-exposure measurements of blood pressure and heart rate were recorded and analyzed by ANNOVA Test by SPSS-27. The ambient noise level of the testing room was 44.8 dB.

Results: The findings showed that both systolic and diastolic blood pressure significantly decreased only after exposure to pink noise ($p < 0.05$). Although the heart rate also decreased following exposure to pink noise, the reduction was not statistically significant. No significant changes in blood pressure or heart rate were observed after exposure to white or violet noise.

Conclusion: Exposure to colored noise, particularly pink noise, may help reduce physiological stress responses such as elevated heart rate and diastolic blood pressure in healthy office workers. These findings support the potential use of colored noise as a simple, non-invasive intervention for stress management in workplace settings.

KEYWORDS: Stress; Blood Pressure; Heart Rate; White Noise; Pink Noise; Violet Noise

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INTRODUCTION

A significant part of the workforce around the world contains office and administrative workers [1]. Office workers spend considerable amount of time at their workplace [2]. There are many stressors that office workers are exposed to in their occupational life such as high workload and strict deadlines [3]. Stress is a well-documented factor for High Blood Pressure (HBP) and fast heart rate [4]. A systematic review showed that the rate of HBP was 53.01% [5]. Thus, HBP can negatively influence office workers' personal well-being and occupational performance negatively.

Noise exposure often causes irritation and psychological discomfort [6]. While noise (unwanted sound) can be noticed as a stressor and distractor in work places [7], listening to music or desirable sound can reduce stress and its drawbacks [8]. One type of noise is colored noises. Colored noises represent different frequency distributions based on the logarithmic ratio of power to frequency. They are named by their spectral similarities to light frequencies [9]. White noise is the most popular colored noise. It is a masking noise which covers unwanted background and peak noises [10]. On the other hand, while pink noise has the same ability for covering background noises, it is smoother and rougher than white noise because when its frequency increases, its intensity decreases [7]. Violet, another colored masking noise, or purple noise is a sharp noise, whose intensity increases by increasing frequency; it has high energy in high frequency [9].

The results of a study showed that music helps people feel more comfortable by reducing sympathetic activity [8]. Another study revealed that using sound is a technique for reducing anxiety [10]. On the other hand, colored noises, especially white noise, can enhance cognitive performance by altering signal to noise ratio [7]. Another study in 2022 was conducted to explore the effect of white noise on anxiety, pain and hemodynamic parameters in patients undergoing open heart surgery. The results showed that white noise reduced blood pressure, pulse and pain [11]. In another study, researchers found that white noise can decrease anxiety by reducing pulse rate but it did not affect blood pressure [12]. On the other hand, in another study that both pink and white noise were used, results showed they did not affect blood pressure or heart rate [13]. Most studies on colored noises have focused on patients, leaving their effects on healthy individuals, especially in workplaces, largely unexplored. Additionally, research has mainly examined white noise, while the impacts of

other colored noises, particularly violet noise, remain unclear.

Given the contradictory findings and Insufficient information in existing research, our study aimed to assess the effects of different colored noises (white, pink, and violet) on heart rate and blood pressure in healthy office workers. The goal was to identify the most effective frequency spectrum for reducing stress-related physiological responses.

MATERIALS AND METHODS

Design and sample

This Repeated Measures Design research was conducted among office employees without a history of cardiovascular disease to evaluate the effects of colored noises on blood pressure and heart rate. An official request invitation was sent to a list of office staff who were working in the oil health and treatment headquarters. A total of 43 employees voluntarily participated (27 of the participants were male and 16 of them were female). Informed consent was obtained from all subjects.

The demographic questionnaire

Participants completed a self-reported demographic questionnaire, including information on gender, age, work experience, and history of hearing, neurological and cardiovascular issues, smoking cigarette and high sensitivity to sound.

Hearing Assessment

The hearing of the samples was measured by using a MADSEN model 622 audiometer at frequencies of 500, 1000, 2000, and 4000 at an intensity of 15 dB [14]. At the end of the screening, only participants with normal hearing thresholds were eligible to take part in this study. All the participants were told that if they felt dissatisfied or uncomfortable during the experiment, they could freely withdraw from the study.

Procedure

All participants were aged 25 to 55 years, right-handed. Based on the information obtained from the participants' reports, individuals with a history of cardiovascular disease HBP, neurological or hearing disorders, smoking cigarette or high sensitivity to sound were excluded. Additionally, those unable to sit for 30 minutes due to physical limitations were not included in the study.

Before starting the research, the process of this

study was fully explained to the participants, and they expressed their consent to participate. The process of this study was approved by the ethics committee of Tarbiat Modares University (the approval code of ethics IR.MODARES.REC.1402.161). The whole process was done according to the rules and regulations and all methods were performed in accordance with the relevant guidelines and regulations.

In simulating sound conditions, the participants were exposed to 4 types of sound environment: background noise (normal office sounds), pink sound 65dB, white noise 65dB, and purple noise 65 dB. Since exposure to 70dB sound has been reported to cause discomfort in the participants [1], 65 dB sound was used. White and pink sounds were made using Adobe Audition software (V22.4.0.49, Adobe Inc) and purple sound was made using MATLAB software [15]. Colored noises were played by using a TESCO Bluetooth speaker that was placed 60 cm behind the participants. Sound was measured in A-weighted equivalent continuous sound level(LAeq), which is commonly used for measuring loudness and “eq” describes time-averaged [16]. A calibrated CEL110 sound meter was used for measuring sound near the participants’ ears.

The experiments were conducted across four different phases in a private room at the Health and Treatment Headquarters of the Oil Industry in Tehran. To minimize external distractions, only the participant and the experimenter were present in the office. All participants performed the experiment under same controlled lighting conditions (mean = 379 lux, standard deviation = 47.46) and temperature (mean = 25.19°C, standard deviation = 0.51°C). In advance, participants were instructed to get sufficient sleep (8 hours) the night before the experiment and to avoid consuming caffeine, theine, or painkillers for at least 1 hour prior to each phase of the study [17].

In each phase of the study, participants typed a passage from an elementary book for 20 minutes. Working with keyboard and typing is a common task for most office workers [18], and they were allowed to correct any mistakes they made during the session. Participants typed at their own pace. Before the study began and after 20 minutes of typing, participants’ blood pressure and heart rate were measured. A calibrated digital sphygmomanometer (Omron) was used for these measurements, which was also capable of recording heart rate. The device assessed systolic (first number) and diastolic (second number) blood pressure, and heart rate. The sphygmomanometer

stored the data and displayed it on a screen. The cuff was placed around the participant’s left arm, ensuring that the sensor was positioned directly on the inside of the elbow. The measurement was then taken by pressing the start button, allowing the device to record the systolic and diastolic pressures along with the heart rate of each participant.

Sound conditions

In the first stage, all participants performed the typing task in the presence of background noise (typical office noise) at 44.86 dB (SD = 6.17). In the second, third, and fourth phases, the same participants completed the tests under different colored noise conditions: pink noise (65.18 dB, SD = 0.33), white noise (65.14 dB, SD = 0.35), and purple noise (65.14 dB, SD = 0.35), respectively. To minimize overlapping effects, a one-week interval was maintained between each phase. Each participant completed all four phases on the same day and at the same time each week. The duration of each stage was 20 minutes. This within-subject study design ensured that all participants completed all four phases. Five minutes before the start of each test, participants arrived at the office to mentally and physically adjust to the experimental conditions [14, 19].

Statistical analysis

ANOVA test was used to analyze the data obtained from the results obtained from the participants in the 4 mentioned audio positions, with pink, white, purple, and background sounds as independent variables. Pearson’s correlation coefficient test was used to evaluate the relationship between Participants’ BMI, age and Systolic and Diastolic Blood Pressure and Heart Rate.

P-value <0.05 was used to determine the significance of the results. IBM SPSS Statistics27 was used for statistical evaluation of data.

RESULTS

43 office workers participated in the current study. 27 of them were male (62.8%) and 16 women (37.2%). The average Body Mass Index (BMI) was 25.99 ± 3.78 , with only five participants classified as overweight (BMI > 29.99)[20]. Correlation test (Bivariate) showed that there was not any correlation between participants’ BMI and age with their systolic and diastolic blood pressure or Heart Rate (Table 1).

ANOVA Test was used for the statistical analysis of the data to investigate the effect of colored noises. In order to check the normality of the variables in

the research, the Kolmogorov-Smirnov test was used. The results of this test showed that the quantitative variables of the research had a normal distribution ($p\text{-value} > 0.05$).

Results indicated that systolic and diastolic blood pressure, as well as heart rate, remained unchanged during the first phase (exposure to background office noise). It can be considered that the current study and normal typing task did not change Blood Pressure and Heart Rate. On the other hand, exposure to pink noise caused a decreased in Systolic and Diastolic Blood Pressure; these decreases were statically approved ($p < 0.05$). Whereas, participants' Heart Rate decreased, it was statistically meaningless ($p > 0.05$). Changes due to exposure to white noise and purple noise were negligible and not reliable due to $p\text{-value} > 0.05$ (Table 2)

As shown in Figure 1, there was no significant change in participants' Systolic Blood Pressure after exposure to background noise, white noise and purple noise. On the other hand, exposure to pink noise obviously decrease Systolic Blood Pressure.

Average diastolic blood pressure shows exposure to white and purple noises increased it but this increase was not statistically significant. Changing in Diastolic Blood Pressure followed Systolic Blood Pressure in exposure to pink noise. Diastolic Blood Pressure decreased from 78.60 to 75.51 in exposure to pink noise, which was statistically approved. (Figure 2)

Changing in participants' Heart Rate was negligible in exposure to all noise conditions. In contrast, while heart rate decreased after exposure to pink noise, this change was not statistically significant ($p < 0.05$). (Figure 3).

DISCUSSION

Our results showed that pink noise significantly decreased both systolic and diastolic Blood Pressure ($p < 0.05$). Systolic blood pressure decreased from 114.42 mmHg to 108.30 mmHg, and diastolic blood pressure decreased to 75.51 mmHg from 78.60 mmHg following exposure to pink noise. Although the heart

Table 1. Demographic characteristics of participants

| Independent variable | | Frequency N (%) | Mean | SD |
|----------------------|--------|-----------------|-------|------|
| Gender | Male | 27 (62.8) | | |
| | Female | 16 (37.2) | | |
| Age | 25-35 | 13 (30.2) | | |
| | 35-45 | 16 (37.2) | 38.77 | 9.21 |
| | 45-55 | 14 (32.6) | | |
| BMI* | ≤29.99 | 38 (88.4) | 25.99 | 3.78 |
| | >29.99 | 5 (11.6) | | |

*BMI: Body Mass Index

Table 2. Mean, standard deviation and ANOVA Analyze of Systolic and Diastolic Blood Pressure under different noise conditions

| Dependent variable | Noise condition | Before exposure | | After exposure | | f | sig |
|--------------------------|------------------|-----------------|-------|----------------|-------|-------|-------|
| | | Mean | SD | Mean | SD | | |
| Systolic Blood Pressure | Background noise | 113.42 | 13.54 | 112.70 | 13.08 | 0.28 | 0.60 |
| | Pink noise | 114.42 | 14.76 | 108.30 | 13.66 | 14.02 | 0.01* |
| | White noise | 110.26 | 12.75 | 109.58 | 14.19 | 0.18 | 0.66 |
| | Purple noise | 110.33 | 13.11 | 109.35 | 13.07 | 0.42 | 0.51 |
| Diastolic Blood Pressure | Background noise | 77.53 | 11.03 | 77.81 | 9.68 | 0.05 | 0.81 |
| | Pink noise | 78.60 | 11.17 | 75.51 | 10.70 | 6.02 | 0.01* |
| | White noise | 75.84 | 8.59 | 77.00 | 10.67 | 2.157 | 0.15 |
| | Purple noise | 75.49 | 10.28 | 77.02 | 8.45 | 2.52 | 0.12 |
| Heart Rate | Background noise | 79.93 | 13.84 | 79.14 | 11.62 | 0.18 | 0.66 |
| | Pink noise | 79.14 | 11.91 | 77.60 | 9.81 | 2.15 | 0.14 |
| | White noise | 80.67 | 12.09 | 79.12 | 10.30 | 1.91 | 0.17 |
| | Purple noise | 77.81 | 10.72 | 77.86 | 10.50 | 0.03 | 0.95 |

$P < 0.05^*$

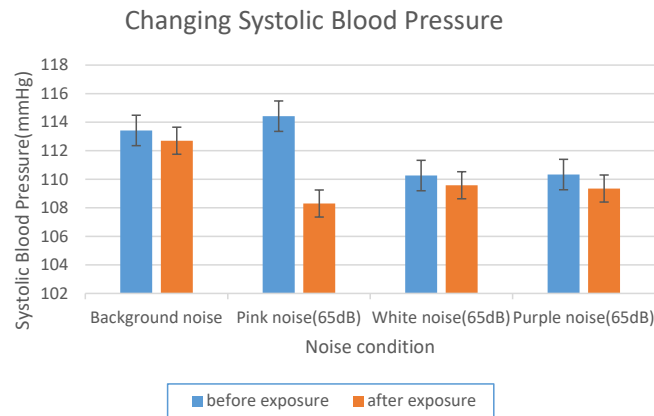


Figure 1. Mean Systolic Blood Pressure Before and After Exposure to Different Noise Conditions

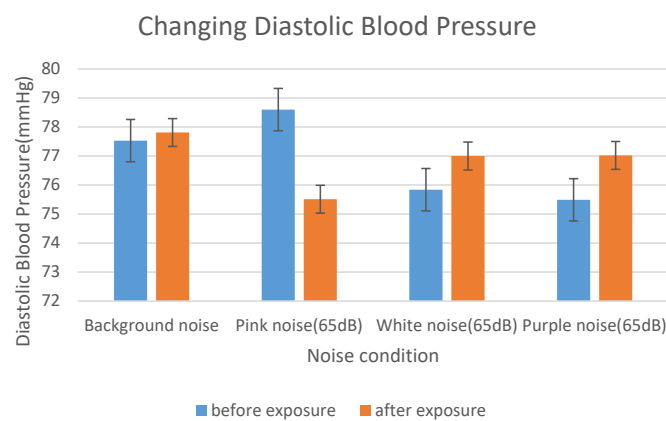


Figure 2. Mean Diastolic Blood Pressure Before and After Exposure to Different Noise Conditions

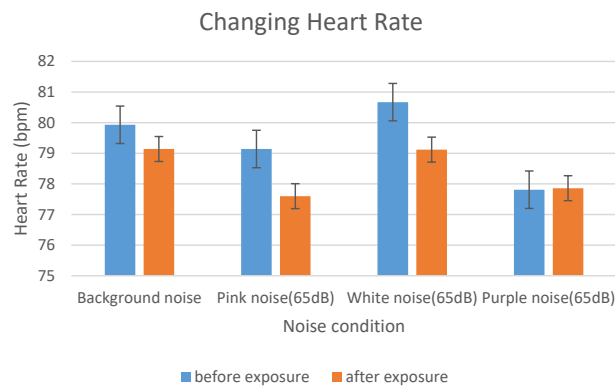


Figure 3. Mean Heart Rate Before and After Exposure to Different Noise Conditions

rate also decreased from 79.60 bpm to 77.14 bpm, this reduction was not statistically significant. In general, we can conclude that pink noise has a relaxing effect. On the other hand, background office noise, white noise and purple noise did not cause any changes in Blood Pressure or Heart Rate.

Just as various factors such as body posture, exerted force, duration, movement repetition, and environmental conditions play a significant role in the

evaluation of musculoskeletal disorders [21], blood pressure is influenced by factors such as excess body weight and smoking. This study had some limitations. We were unable to assess stress hormones, such as cortisol and adrenaline, nor could we evaluate the long-term effects of colored noises. Although only five participants in our study were at the threshold of obesity and none of them had a history of smoking, the potential impact of these factors cannot be overlooked.

Therefore, interpreting changes in blood pressure requires more comprehensive data through continuous monitoring.

Our findings are consistent with a study conducted by Fox et al., which showed that neither white noise nor ambient noise could alter physiological stress indicators such as blood pressure, pulse rate, and electrodermal activity [22]. Another study by Nazan Ilkkaya et al. examined the effects of white noise, ambient noise, and music on anxiety in patients under spinal anesthesia during surgery. Their findings revealed that patient-selected music reduced anxiety, whereas ambient and white noise had no significant impact on anxiety levels [23]. These results align with our results. In contrast, another study reported that listening to white noise reduced pain and stress in newborns, as evidenced by lower heart rates and reduced crying [24]. Similarly, a study conducted on patients undergoing open-heart surgery found that white noise reduced blood pressure, heart rate, and pain perception [11]. The discrepancy between these studies and our findings may be due to differences in the target populations and their health conditions. Another study done among nursing students by Aksoy and Ozturk showed that heart rate and diastolic blood pressure of participants did not change after listening to white noise, whereas their diastolic blood pressure increased. They concluded that white noise can negatively affect anxiety [25]. Based on these findings, we can infer that white noise may not influence blood pressure and heart rate in healthy adults but may have a calming effect on patients or newborns.

In 1993, KAWADA and SUZUKI showed in their study that steady pink noise shortens sleep latency. They announced that people can fall asleep easier when they listen to pink noise. They explained pink noise can mask environmental noise and let people sleep earlier [26]. In 2019, Acosta et al. showed that pink noise corresponds with mental activities which is one of the most common signal in biological system [27]. This may explain why pink noise is often considered the most effective colored noise for improving sleep quality [28]. One of the recent research projects showed that sleep improves the immune system and decreases stress and anxiety. A study using pink noise found that it positively affects cardiovascular function by promoting efficient blood flow [29]. This improves the cardiovascular system, which can explain our findings. However, another study reported that neither white noise nor pink noise influenced cortisol levels or heart rate, which are key indicators of stress [13]. Overall,

we conclude that pink noise may promote relaxation by masking environmental noise and influencing neurological and biological systems.

Future research should explore the prolonged impact of colored noises on cardiovascular health and stress regulation. Additionally, further studies are needed to investigate their effects on individuals with hypertension.

CONCLUSION

Pink noise significantly reduced both systolic and diastolic blood pressure, while its impact on heart rate was minimal (showing only a slight decrease). In contrast, white and violet noise had no significant effects on either blood pressure or heart rate. These findings suggest that pink noise may serve as a practical, non-invasive intervention to alleviate physiological stress responses in office environments. However, further studies with larger samples and diverse populations are needed to confirm these effects and to explore the underlying mechanisms.

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Conflict of Interest

The authors declare no conflict of interest.

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Author's Contributions

Study Conception or Design: SM Mousavi, A Khavanin, S Vosoughi
 Data Acquisition: SM Mousavi, A Khavanin, S Vosoughi
 Data Analysis or Interpretation: SM Mousavi, A Khavanin, S Vosoughi
 Manuscript Drafting: SM Mousavi, A Khavanin, S Vosoughi
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 All authors have approved the final manuscript and are responsible for all aspects of the work.

AI Statement

The authors confirm that no AI tools or services were used during the preparation of this work.

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