Spectral Content (colour) of Noise Exposure Affects Work Efficiency

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Abstract

Introduction: As part of an effort to enhance the efficiency of workers, experiments relating to three types of noise exposure were conducted. Previous studies have proved that pink noise can cause a brain wave to reach a lower potential. In this study, we utilized physical methods, in cognitive experiments, to understand the impacts that three colour noises have on working efficiency. Subjects and Methods: All 22 participants were exposed to a sound environment of quiet, red, pink and white noises respectively. After a laboratory experiment, details of psychomotor speed, continuous performance, executive function and working memory were recorded. Results: Red, pink and white noises were significantly positive in comparison with the quiet environment of the psychomotor speed test. As for the continuous performance test, pink noise gave the only significantly positive result. Red, pink and white noise resulted in a better executive function test. Red and pink noise showed significantly positive improvement, while white noise was significantly positive in comparison with the quiet environment of the working memory test. In addition, the results from the comfort questionnaires showed that red and pink noise increase the possibility of better judgment, implementation, and overall environment. Conclusion: At present time, it is considered that noise has negative effects on hearing and health. However, experimental results show that certain noise can enhance environmental comfort. It is feasible, in the future, to use knowledge of colour noises to improve productivity in a workplace with a healthy environment.

Keywords: Human performance, pink noise, red noise, subjective comfort, white noise

INTRODUCTION

Exposure to high levels of noise in industry factory is associated with a number of effects on health manifested in various psychosocial responses such as annoyance, disturbance of daily activities, sleep and performance and in physical responses, such as hearing loss, hypertension and ischemic heart disease.¹² While the open-plan office is now widespread in the workplace, it appears that noise is a major nuisance factor in open-plan offices in spite of a relatively low noise level(less than 65 dB(A)).³ In general, the higher the decibel numbers of sound, the greater the health hazard. However, when the number of sound decibels is not high, the degree of influence on people may vary depending on the sound characteristics.

In audio engineering, physics, and many other fields, the colour of noise refers to the power spectrum of a noise signal. The practice of naming kinds of noise after colours started with white noise, a signal whose spectrum has equal power within any equal interval of frequencies. That name was given by analogy with white light, which was assumed to have such a flat power spectrum over the visible range. Other colour names, like pink, red, and blue were then given to noise with other spectral profiles, often (but not always) in reference to the colour of light with similar spectra.

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Noise often has detrimental effects on performance. Under most circumstances, information processing is disturbed by environmental noise and other non-task compatible distractors. However, researchers have recently reported that under certain circumstances individuals with attention problems appear to benefit from the addition of specific forms of environmental noise. Typically, this facilitative effect has been limited to non-vocal background music on simple arithmetic task performance, but Stansfeld et al. found just that under certain conditions even road traffic noise can improve performance on episodic memory tasks, particularly in children at risk of attention problems and academic underachievement. Furthermore, Söderlund et al. have demonstrated that adding auditory white noise to the environment enhanced the memory performance of children with Attention Deficit Hyperactivity Disorder (ADHD)-type problems but disrupted that of non-ADHD control children. Stochastic resonance, a phenomenon whereby signal processing is enhanced by the addition of random noise, has been widely demonstrated across various modalities, including visual, auditory, tactile and cross-modal forms of processing. Of particular interest are findings that auditory noise has the capacity to enhance some aspects of human cognitive performance, such as the speed of arithmetical computations.

Meanwhile, some recent studies showed related evidence. For example, in 2010, light music, an example belonging to pink noise, is proved beneficial for elder people to improve their sleep quality as a long term effect. Moreover, in a previous study, the steady pink noise with intensity of 35 dB, 40 dB, 50 dB and 60 dB was used to stimulate four participants during sleep and they believed that pink noise could improve the sleep quality of participants. However, it is clear that this conclusion was based on significant increase of light sleep period (especially stage 2) accompanied with declined duration of rapid eye movement. In the brain synchronization study, it has demonstrated that the pink noise could synchronize brain wave and induce brain activity into a specialized state, that is, in a lower complexity level.

Sezici’s study showed that playing of white noise significantly decreased the daily crying durations and increased the sleeping durations of the colicky babies compared to swinging in both groups. In the literature, parents emphasized that playing of white noise was quite beneficial in relieving pain among crying colicky babies. In their studies, Kucukoglu et al. and Karakoc and Turker revealed that the pain scores of the newborns who were made to listen to white noise were observed to decrease compared with those of the newborns in the control group. White noise encompasses all characteristics of sounds within the range of human hearing. It has been used in the treatment of tinnitus, insomnia, masking unwanted sounds, and provision of relaxation.

Zhou et al. demonstrated that steady pink noise has significant effect on reducing brain wave complexity and inducing more stable sleep time to improve sleep quality of individuals. In total, 42 elderly people (21 using music and 21 controls) completed the study, and there was some indication that soft slow music yielded higher improvement on some of the parameters, which are worthy of further investigation.

A tabulated list of the effects observed in previous studies with colour noise exposures is shown in Table 1.

Several experiments have demonstrated that the detrimental effect of office noise on worker attitude and performance can be significantly reduced through the use of masking noise. For instance the experimental study performed by Haka demonstrated that the performance of operation span tasks, serial recall and long term memory tasks were all improved when masking noise was used; and the field study performed by Hongisto indicated that masking noise significantly reduced disturbance of worker attitudes towards concentration caused by office noise. Masking noise achieves this improvement through reducing the intelligibility of nearby speech. In addition, Vassie

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**Table 1: A tabulated list of the effects observed in previous studies with colour noise exposures**

| Colour noise | Summary of results | References |
|--------------|--------------------|------------|
| White noise  | Noise exerted a positive effect on cognitive performance for the attention deficit hyperactivity disorder (ADHD) group and deteriorated performance for the control group, indicating that ADHD subjects need more noise than controls for optimal cognitive performance. | Söderlund et al. |
| Pink noise   | An inhibition pulse from the cortex may suppress the activation of reticular formation, which could make sleep under a steady noise deeper. However, the meaning of a depressed proportion of rapid eye movement under steady pink noise is not clear. | Suzuki et al. |
| Pink noise   | This study demonstrates that steady pink noise has significant effect on reducing brain wave complexity and inducing more stable sleep time to improve sleep quality of individuals. | Zhou et al. |
| White noise  | Playing of white noise was found to be a more effective nonpharmacological method on crying and sleeping durations of colicky babies than swinging. | Sezici and Yigit |
| White noise  | Having colicky babies listen to white noise decreases their crying durations and increases their sleeping durations. | Balci, 2006 |
| White noise  | White noise was found to be effective for this sample; however, there is a dire need for extensive research on white noise and its use with this vulnerable population. | Kucukoglu et al. |
| White noise  | According to the results, white noise is an effective nonpharmacological method to control pain, reduce crying time, and positively affect vital signs. | Karakoc and Turker |
et al.\textsuperscript{[26]} indicated that participants rejected the brown masking noise delivered through earphones as it caused irritation and discomfort. Future studies should also consider other types of masking noise and should measure the level and duration of the masking noise.\textsuperscript{[26]}

It is well-known that any human action results from brain activity, which is affected by light and sound. Too much acoustic energy causes hearing loss, impaired human nerves, and emotional disorders.\textsuperscript{[27,28]} However, sound play also very important role for people. According to previous researchers, not only white noise can create shading effect, but pink noise can improve sleep quality. Most people in the workplace are in the office or in the service industry, not in the noisy working environment for the factory. Creating a quiet environment is sometimes not easy. However, adding some sounds to enhance the work efficiency and reduce the work pressure of low-noise environment should be an issue worth exploring. Therefore, this study wanted to understand the effects of three different colours noise exposure. In the past, there were not many studies in this regard. Therefore, the goal of the current study is to test the hypothesis that adding another sound in a low background noise environment may increases productivity and comfort.

**SUBJECTS AND METHODS**

**Participants**

Twenty-two healthy college students were enrolled in this study. The mean age of the participants was 22 years. All participants reported no medical history of neurological disease, hypertension or heart disease. A machine called an audiometer was used to produce sounds at various volumes and frequencies. The participants being tested listened to sounds through headphones and responded when they hear them by pressing a button. A pure tone audiogram was performed by a trained health care professional at the beginning of the study for each participant, and the hearing acuity of the participants was determined to be normal, with the thresholds of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz being less than 15 dB. The participants received financial compensation for their participation in the experiment. Informed consent was obtained from all participants.

**Presentation of noise**

During this experiment, four sound conditions were used, relating to the three types of masking sound (red noise, pink noise, white noise) and a condition, which consisted of a wide band background noise. White noise is a signal with a flat frequency spectrum when plotted as a linear function of frequency. Red noise will refer to a power density which decreases 6 dB per octave with increasing frequency (density proportional to 1/f$^2$). The frequency spectrum of pink noise is linear in logarithmic scale, and the spectral power density, compared with white noise, decreases by 3 dB per octave (density proportional to 1/f). The noise level within the room used in the study was measured using a Cirrus Type 832C sound level meter. Thirty second SPL samples, $L_{Aeq,30s}$, were measured over an period of an hour. Noise levels ranged from an $L_{min}$ of 41 dBA to an $L_{max}$ of 50 dBA. Measurements performed on successive days identified similar ranges of $L_{min}$ and $L_{max}$.

The signal source of masking sound was sent through a desktop computer to a Bluetooth speaker (BOSE SoundLink Mini). The sound level of each colour noise exposure was about 47 dBA when turning on the speaker and the background noise (without adding colour noise) was 44 dBA. Background noise had a decibel (dBA) value of three decibels (dBA) difference compared to the noise exposure scenario of three different colours, so that means that the sound energy of the colour noise exposure scenario was double that of the original silence.

**Outcome measures**

Over the years, different scholars have given their definitions of efficiency, and different scholars also have different views and explanations for it. Therefore, it is not easy to offer a precise definition of work efficiency. Among many offerings, the definition of work efficiency includes “work response time”, the time when the work instruction is received plus the response time, and “work execution processing time” the time it takes for each task from the reaction to the completion. “Working memory” refers to the processing of tasks for the content of the current short-term memories. Cognitive function is concept that covers several functions of the brain such as attention, executive function, processing speed, learning and memory. Information processing and response speed are basic cognitive function, which is needed for more complex functions such as working memory. We measured cognitive performance via a battery of standardized cognitive tests. If improvements were observed in cognitive performance, this would not only have important benefits for employees, but benefits for the organization in terms of the potential for increased productivity. The main outcome measures for this study were those of four laboratory tests: Psychomotor Speed Test, Continuous Performance Test, Executive Function Test, and Working Memory Test. These tests were presented in a random order. Participants completed them on individual laptops in a laboratory with one of the testers present. The Psychomotor Speed Test measures Simple Reaction Time (SRT), general alertness and motor speed through delivery of a known stimulus to a known location to elicit a known response. The Continuous Performance Test – Identical Pairs (CPT-IP) requires the identification of identical stimulus pairs within a continuously presented series of stimuli. The Trail Making Test (TMT) is a widely used test to assess executive function, and it is a neuropsychological test of visual attention and task switching. It consists of two parts
which the participant is instructed to connect a set of 25 dots as quickly as possible while still maintaining accuracy. The test can provide information about visual search speed, scanning, speed of processing, mental flexibility, as well as executive functioning. Currently, the Wechsler Adult Intelligence Scale (WAIS) is the most commonly used instrument in the armamentarium of clinical neuropsychologists.\(^{[29,30]}\) This test involves letter sequences and tests one’s ability to think logically and analytically. However, the Wechsler Adult Intelligence Scale-III and IV Letter Number Sequencing are not appropriate for non-alphabetic cultures. The Taiwan’s Odd-Even Number Sequencing Test (TOENST), as proposed by the Department of Psychology, National Taiwan University,\(^{[31]}\) was adopted to replace the Letter Number Test. Participants need to rearrange and read the Arabic numerals in a series. The way to read out the series is: “read out the odd numbers in ascending order and then the even numbers in descending order.” For example, the random numbers 7, 2, 8, 6, 3 is incremented by an odd number (3, 7) and decrements by an even number (8, 6, 2), so the answer is 3 7 8 6 2.

The comfort of the sound field environment was evaluated by a closed questionnaire, and the subjective comfort of the participant’s sound field environment was measured by the semantic differential method. There were mainly seven closed questionnaires in the questionnaire design, with “no feeling” in the middle (0 point). From middle to the left indicates that the ability deteriorates and worsens. Each left one grid is −1, the left two grids are −2, and so on. The middle to the right means that the ability to become better, every right one grid is +1, the right two grids is +2, and so on.

**Experimental protocol**

Participants were tested in the same laboratory. Subject to the participants’ available time, the experiment was conducted under conditions of quiet (without noise), red noise, pink noise and white noise exposure. Before each experiment, the participants adopted a random method to determine the sound field exposure situation and the participants were not informed of the kind of sound scenario. The order of the four sound conditions (quiet, red, pink, white) was randomized. Ten minutes before the experiment was started, the participants were physiologically and psychologically adapted to the laboratory environment before they started the experiment. Each participant had to perform four tests and complete questionnaires in each of the four sessions in the experiment, and the order of the four tests was randomized. There was a five-minute break between each test. During the break, the sound exposure was on and the sound exposure was not terminated until all sound field exposure conditions had ended. After finishing four tests, participants filled in the sound field comfort evaluation questionnaire. During the filling in process, the sound continued. The flowchart in Figure 1 illustrates the experimental protocol.

A within-subject design was used in the experiment with one independent variable, i.e. sound condition. Five dependent variables, including four objective parameters (psychomotor speed test, continuous performance test, executive function test, and working memory test) and one subjective perception, were collected to explore work efficiency in this study.

**Statistical analysis of data**

The study was interested in evaluating the effectiveness of colour noise exposure. The approach considered was to measure the performance of a sample of participants before and after colour noise exposure, and analyse the differences using a paired sample t-test. IBM SPSS Statistics Version 20 was used to determine whether there were any statistically significant differences between the means of independent groups. Data from the completed questionnaires were stored in a database and transported in and subsequently analysed using the statistical program SPSS.

**RESULTS**

The results of the four tests conducted in this current study are summarized in Table 2. For each simple reaction time test, 10 sets of tests were completed. In the simple reaction time test, the average response time was better in red noise exposure scenario (0.565 seconds) than in the pink noise exposure scenario (0.602 seconds) and in the white noise exposure scenario (0.609 seconds). The variances of red noise exposure scenario (0.005 seconds) and pink noise exposure scenario (0.008 seconds) were lower than the white noise exposure scenario (0.013 seconds) and the quiet scenario (0.023 seconds). From the average of 10 test results, there was a very significant difference between the three noise exposure scenarios, red noise exposure \(P < 0.001\), pink noise exposure \(P < 0.001\), and white noise exposure \(P < 0.001\) and the quiet scenario, as shown in Figure 2.

Compared with the average correct rate in the continuous performance test, 93.6% of the pink noise exposure situation is better than 91.7% of the red noise exposure situation and 91.1% of the white noise exposure situation, and the three kinds of noise exposure are better than 88.8% on the quiet situation. Among the 22 participants, half of the respondents achieved 93.3% correct rate on red noise exposure, 93.3% on pink noise exposure, 93.3% on white noise exposure, and they all scored better than 90.0% in the quiet situation. The average correct rate of the test showed that there was a slight improvement over the quiet scenario for all of the red noise scenario, the pink noise scenario, and the white noise scenario. The paired t-test showed significant differences \(P < 0.05\) between the pink noise exposure scenario and the quiet scenario in the continuous performance test, Figure 3.

In the executive function tests, comparing the average time it takes to complete the test, it shows the red noise exposure...
scenario (21.37 seconds) is superior to the pink noise exposure scenario (22.31 seconds) and the white noise exposure scenario (23.11 seconds), all of which are better than the quiet scenario (24.54 seconds). The best test results (minimum) showed that the red noise exposure scenario (12.00 seconds), pink noise exposure scenario (10.73 seconds), white noise exposure scenario (13.13 seconds) were also better than the quiet scenario (15.33 seconds). The average finishing time of the tests showed that the red noise exposure situation, the pink noise exposure situation and the white noise exposure situation are better than the quiet situation. As shown on Figure 4, the paired t-test of executive function tests showed significant differences between the red noise exposure scenario ($P < 0.001$), the pink noise exposure scenario ($P < 0.001$), white noise exposure scenario ($P < 0.001$) and the quiet scenario.

The average score of the working memory test showed that the red noise exposure situation (18.8 points) was superior to the pink noise exposure situation (17.3 points) and the white noise exposure situation (15.9 points) and the quiet situation (14.4 points). In a comparison of variance, the red noise exposure (5.1 points) and the pink noise exposure (6.9 points) were significantly lower than the white noise exposure (11.2 points) and noiseless exposure (9.3 points). The paired t-test analysis showed that in the working memory situation.

Table 2: Means and variances of SRT, CPT-IP, TMT, TOENST in four different sound field environments

|           | SRT (s)     | CPT-IP (%) | TMT (s)     | TOENST (points) |
|-----------|-------------|------------|-------------|-----------------|
| Quiet     | 0.662 ± 0.023 | 88.8 ± 1.0 | 24.54 ± 26.33 | 14.4 ± 9.3      |
| Red noise | 0.565 ± 0.005 | 91.7 ± 1.1 | 21.37 ± 20.23 | 18.8 ± 5.1      |
| Pink noise| 0.602 ± 0.008 | 93.6 ± 0.3 | 22.31 ± 20.94 | 17.3 ± 6.9      |
| White noise| 0.609 ± 0.013 | 91.1 ± 0.4 | 23.11 ± 28.86 | 15.9 ± 11.2     |
test, the red noise exposure ($P < 0.001$), the pink noise exposure ($P < 0.001$), the white noise exposure ($P < 0.01$), the three noise exposure all had a significant difference as compared with the quiet situation, as shown on Figure 5.

As shown in Table 3, compared with the quiet situation, both the red noise and the pink noise exposure in the simple reaction time test, the executive function test and the working memory test all showed significant differences ($P < 0.001$). The white noise exposure was very significantly different ($P < 0.001$) in the simple reaction time test, and there was a significant difference ($P < 0.01$) in the working memory test. However, only pink noise exposure was significantly different ($P < 0.05$) in the continuous performance test.

A statistical analysis of the sound field comfort questionnaire showed that, the questionnaire had a Cronbach’s alpha score of 0.772. Generally, a questionnaire with a Cronbach’s alpha score between 0.7 and 0.9 is considered to be of good reliability. As shown in Table 4, the subjective comfort evaluation statistics of the sound field environment indicated a highest and lowest score of 0 and −2, a little worse in the quiet scenario, while the scores between −1 and 3 were slightly worse to good in the red noise scenario; the scores between −1 and 2 were slightly worse to better in pink noise scenario; however, the scores between −3 and 1 represented a worse to slightly better result for the white noise scenario. The sum of the scores of the subjective evaluation in the sound field were −40 (average rating −0.26), +81 (average rating 0.53), +38 (average rating 0.25), −94 (average rating −0.61) for quiet, red noise, pink noise, and white noise scenarios, respectively.

**DISCUSSION**

Of the four trials, there were three significant ($P < 0.001$) increases in scores for red noise exposure and pink noise exposure, possibly reflecting improvements in work...
efficiency. Literature explains that white noise exposure can serve as a masking sound, and this may improve work efficiency. Two tests showed a significant ($P < 0.001$) increase in performance, with a significant ($P < 0.01$) increase in one trial also corroborating previous studies. In brain synchronization studies, pink noise exposure has been shown to synchronize the brain and induce brain activity to lower its potential,[13] and to exclude the effects of the outside world for purposes of concentrated processing. Except for the slight significant difference ($P < 0.05$) in white noise exposure, the continuous performance test was the only one that did not show very significant results. Participants may all have been preoccupied with the test, so the average correct rates are above 90%. Even the correct rates of two participants reached 100% when exposed to all four sound situations, and there were three participants with a 100% correct rate when exposed to three scenarios.

In the continuous performance test, the correct rate of non-exposure was about 88.8%, which of red noise, pink noise, and white noise were 91.7%, 93.6%, and 91.1%, respectively. Half of the 22 participants achieved a correct rate of 93.3% under the conditions of red noise exposure, pink noise exposure and white noise exposure, all of which were higher than the 88.8% correct rate of no noise exposure. The average score of the test results showed that a red noise exposure scenario, pink noise exposure scenario, and white noise exposure scenario are slightly better than the quiet scenario, which means that with the exposure to colour noise, the correct rate will rise and attention will be slightly improved.

Because the exposure of the participant’s living environment to the noise itself, might affect the questionnaire data, the type of accommodation should be indicated on the comfort questionnaire, and whether or not there is any noise exposure should be indicated in the closed questionnaire. In this study, there were three home participants exposed to noise, there were three home participants who sometimes had noise exposure. Of these six participants, five of the participants had different answers from the others, indicating a larger numerical increase in white noise.

The scores of the questionnaire results in the comfort of colour noises environment did not fully match the test data. Participants were randomly interviewed after the experiment. They said that with the additional sound increases, they felt that the sound interference, and the selection value should be less favourable. The laboratory background sound level was 44 dBA in the quiet scenario. The participants experienced significant changes to sound of 47 dBA when exposed to colour noise. Moreover, because the experimental exposure scenario was determined in a random manner, it was difficult to remember which previous test scores were selected. Scenario comfort evaluation is felt on a subjective basis, but participants may have had preconceptions when completing the questionnaire, thus affecting the final score.

Table 3: Paired t-test analysis of three colour noise exposure situations compared with quiet situations

| Variables                  | Paired differences | Sig. |
|----------------------------|--------------------|------|
|                            | Mean   | Std. Dev. |      |
| Simple reaction test       | Quiet vs. red noise | 0.10 | 0.15 | 0    |
|                            | Quiet vs. pink noise | 0.06 | 0.14 | 0    |
|                            | Quiet vs. white noise | 0.05 | 0.18 | 0    |
| Continuous performance test| Quiet vs. red noise | −0.03 | 0.08 | 0.111|
|                            | Quiet vs. pink noise | −0.05 | 0.09 | 0.025|
|                            | Quiet vs. white noise | −0.02 | 0.10 | 0.277|
| Executive function test    | Quiet vs. red noise | 3.16 | 4.46 | 0    |
|                            | Quiet vs. pink noise | 2.47 | 4.97 | 0    |
|                            | Quiet vs. white noise | 1.42 | 5.42 | 0    |
| Working memory test        | Quiet vs. red noise | −4.45 | 2.56 | 0    |
|                            | Quiet vs. pink noise | −2.95 | 2.19 | 0    |
|                            | Quiet vs. white noise | −1.50 | 2.46 | 0.009|

Table 4: Subjective comfort evaluations of four sound environments

| Variables                  | Quiet  | Red noise | Pink noise | White noise |
|----------------------------|--------|-----------|------------|-------------|
|                            | Mean   | 0.53      | 0.25       | −0.61       |
| Median                     | 0      | 0         | 0          | −1          |
| Std. deviation             | 0.51   | 0.92      | 0.67       | 0.82        |
| Variance                   | 0.26   | 0.84      | 0.45       | 0.67        |
| Minimum                    | −2     | −1        | −1         | −3          |
| Maximum                    | 0      | 3         | 2          | 1           |
Although the results of the environmental comfort questionnaire were not as expected, the overall percentage of participants who felt slightly better or above were 48.8%, 32%, 9% for participants exposed to red, pink, white noise, respectively.

The results of this study show that exposure to the three kinds of colour noises, red, pink and white noise yields significantly better results in the Psychomotor Speed Test, Continuous Performance Test, Executive Function Test and Working Memory Test, which proves that these three kinds of sound field environments on the office work-type job site might improve work efficiency. The sum of the questionnaire scores on subjective comfort of the sound field environment showed that red, pink, and white noise exposure, were better than the original no noise exposure of the sound field, and this result implies that the three colour noise sound fields seem to make the white-collar work patterns a better workplaces not only by improving productivity, but also by making workers feel comfortable. Because white noise is equal energy at each frequency, it can cover the sounds that do not want to be heard around the environment. Pink noise might be due to neurons in the hypothalamus synchronously resonating with pink noises in the low oscillation frequency band, making slow rhythms and dominating brain waves. In addition, the power density of high frequency in red noise is even lower than these in pink noise and may therefore affect neurons in the hypothalamus even more, leading to information more speedily reaching the cerebral cortex through the hypothalamus and to faster transmission of motor messages through the hypothalamus.

The concept of the open-plan office is now widespread in the workplace. While offering many advantages in terms of layout and facilitating communication between colleagues, this way of organising the workspace had two major disadvantages. The feeling of privacy is lessened and noise level is increased causing discomfort for individuals working in this type of environment. It appears that noise is a major nuisance factor in open-plan offices in spite of a relatively low noise level. The noise nuisance experienced in open-plan offices affects work satisfaction, and this exposure to noise can reduce employee performance depending on the types of task to be carried out and the characteristics of the noise present in the workplace. The current research suggests that creating a colour noise environment through a loudspeaker or headphone might improve some aspects of cognitive performance in different workplaces. Many studies in the past have proved that noise has a negative influence on human hearing, cardiovascular systems, and emotions and so on. However, the three colour noises are applied to the original sound field environment. Therefore, if the background noise of the workplace is already too high, it would not be in order, for health reasons, to further add colour noise.

CONCLUSION

The results of this study show that participants perform significantly better in Psychomotor Speed Test, Continuous Performance Test, Executive Function Test and Working Memory Test. Therefore, colour noise may be used in the future to improve a workplace sound field environment, so that white-collar workers have a better working environment. Using physical stimuli of red, pink and white noises to improve worker productivity may prove to be a new approach towards productivity improvement that may provide fewer side effects than traditional methods such as drinking refreshing beverages. The introduction of the sounds represents a simple, low-cost, non-invasive improvement.

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Conflicts of interest

There are no conflicts of interest.

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