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Article

Noise Interference Impacts Simple and Choice Response Times during a Lower Extremity Cognitive–Motor Task

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Abstract: Cognitive performance is negatively affected by the presence of noise, which is seen as a distractor and a stressor, especially in hazardous occupational environments. The addition of musculoskeletal fatigue that commonly accompanies occupational work due to noise interruption can further elevate risk and compromise safety. The purpose of the study was to investigate the impact of both individual and a combination of noise interference and physical workload on simple and choice response time tasks. Sixteen healthy male and female participants (age: 20 ± 1 years; height: 169.48 ± 8.2 cm; weight: 67.93 ± 12.7 kg) performed a simple (SRT) and choice response task (CRT) with three Blazepod™ light response time systems by striking with the dominant lower extremity from a seated position while listening to noises from a construction site (65–85dB) through headphones. Participants then performed a low-intensity musculoskeletal fatigue task and completed the above measures again. Response times (RT) (ms) from three trials of SRT and CRT, both without and with noise interference, before (PRE) and after the workload (POST), were averaged, and a 2 (Noise) × 2 (workload) × 2 (task) repeated measure ANOVA and a 2 (Noise) × 2 (workload) repeated measure ANOVA were performed for SRT and CRT, respectively, using JASP at an alpha level of 0.05. Results revealed a significant interaction between workload task (p = 0.041), as well as a main effect significance for the workload (p = 0.007) and noise (p = 0.044). The main effect significance also existed for workload in SRT (p = 0.009) and for noise in CRT (p = 0.002). In SRT, RT was significantly faster during the POST fatigue measure, suggesting a possible cognitive arousal and a learning effect improvement rather than a negative fatigue effect. In both SRT and CRT, as well as individually in CRT, RT was significantly slower due to noise interruption, negatively impacting performance, especially in the more challenging CRT compared to SRT. Thus, findings from the current study suggest that the impact of noise interruption is significant when the complexity of the response task is greater, and the potential cognitive arousal due to the workload and potential learning effects may influence response time performances. Finally, a lower extremity cognitive–motor task demonstrates response time behavior similar to such upper extremity cognitive–motor tasks.

Keywords: response time; noise; cognition; workload; lower extremity; motor task

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1. Introduction

Noise is one of the commonly present and detrimental stressors in the environment, which, when exposed aberrantly, based on type, intensity, and exposure period, can cause serious health issues that include physical, psychosocial, and impaired cognitive and motor performance [1,2]. Noise exposure, especially in hazardous occupational environments, in addition to health effects, can increase the likelihood of accidents and a decline in task performance due to interference with physical and cognitive processes [2]. While different occupations have different types and intensities of noise exposure, thereby leading to deleterious health effects, some of the occupations pose an elevated risk for noise exposure, such as industrial work, construction and roofing, shipyard construction, offshore oil rigs, firefighting, the military, civil aviation, the railway, transportations, agriculture, mining, musicians, and kindergarten schools [3,4]. Among such occupational environments, prolonged exposure to noises that are moderately high (85–90 dB) and high (>90 dB) were reported to be more detrimental, while lower noise levels (40–51 dB) were also reported to cause health deficits [1,5,6]. Of particular importance is the elevated and continuous exposure to occupational noise in the construction industry [2], where noise can manifest from the different construction work tasks, such as excavation and land moving, foundations and structures, brickwork, paving and tiling, electrical and plumbing, as well as moving supplies and heavy machinery [2]. In addition to the physical effects of noise exposure, which include auditory-specific noise-induced hearing loss and damage to the ear membranes, cardiovascular issues such as elevated blood pressure, and psychosocial issues such as stress and sleep disturbance, cognitive and motor performance was reported to be significantly impaired in the presence of uncontrollable noise [7–9].

Reaction, response, and movement times are excellent measures of cognitive and motor task performance when assessed in single-task and, more importantly, in dual-task paradigms and are seen as an indicator of the functional status of the central nervous system [10]. Reaction time is the time interval between the stimulus and the initiation of the response, and response time is the time interval between the stimulus and the end of the response, while movement time is the time interval between the beginning of the response and the ending of the response [11]. The faster the reaction, response, and movement times are, the more successful the task performance and outcomes are, provided the performed response is correct with no errors. Noise interference was reported to more commonly increase reaction times, but it also can decrease or produce no change in reaction times in task performance [1,12,13]. Cognitive and motor performance, vigilance, and efficiency of any task involving cognition, concentration, and attention will be negatively affected by noise. Decreased attention, increased need for effort, and changes in the choice of strategies for performed tasks are commonly seen [6,8,14]. Such negative effects on cognitive and motor performance are of paramount importance in occupational work settings, which leads to a reduction in safety and an elevated risk for task errors and injuries.

Another stressor to cognitive and motor performance and a common occurrence in occupational environments is muscular workload and fatigue, which have been well known to inhibit task performance but are dependent on the workload's intensity and duration. The effect of exercise on cognitive–motor performance is varied, as a high-intensity, short-duration workload does not affect cognitive function [15]; however, sub-maximal prolonged duration workload can cause a reduction in cognitive performance [16]. The beneficial effects of exercise on cognitive performance have been attributed to an increase in physiological and cognitive arousal due to exercise or workload [10]. An inverted "U" relationship between physical activity and cognitive performance has been suggested, but only with caution, as an interpretation of cognitive performance will depend on intensity, duration, and type of exercise, as well as the age and health status of the individuals [10].

Thus, occupational environments commonly have the stressors of noise and muscular fatigue, both of which can be detrimental to occupational cognitive–motor task performance. As such, incorrect responses, missed responses, or even slowed responses to such occupational cognitive–motor tasks can easily be responsible for deficient task performance as well as pose the worker at risk for injuries, given the hazardous nature of the work environment. An example of such an occupational task is driving and operating heavy construction vehicles, where noise and lower extremity fatigue are common and require appropriate and fast responses while driving these vehicles using lower the extremities for the purposes of accelerating and braking based on environmental and traffic cues, thus performing a cognitive–motor task. The fields of human factors and ergonomics have addressed these issues due to excessive cognitive activity, mental workload, and driver distraction during driving tasks. While various contributions to the literature that report the impact of noise on cognitive–motor performance and workload on cognitive–motor performance exist, the literature assessing the simultaneous impact on cognitive–motor performance, with measures of response times, in no-interference and interference conditions, is limited [17]. Additionally, most research involving a color light reaction/response assessment uses the upper extremities for the response task, which usually includes hitting, tapping, or striking the target with the onset of a color light stimulus, either as a simple or choice response task [10,18]. However, lower extremities are commonly used for such cognitive–motor tasks in the everyday environment, such as driving a car on the road with other vehicles and pedestrians and in response to traffic lights [19]. This more specifically applies to occupational environments, such as construction sites, with the operation of heavy machinery or heavy-duty vehicles with an everchanging surrounding environment for the workers. The use of breaks, a clutch, and accelerators with the lower extremity are only some of the cognitive–motor tasks that need to be performed correctly with the correct choice of task and without errors in physically demanding, noisy work environments.

Therefore, the purpose of this study was to investigate the impact of noise interference and a physical workload, both individually and in combination, compared to no-noise and no-workload conditions, on lower extremity simple and choice response cognitive–motor tasks. Based on the past literature, noise interference and physical workload were hypothesized to cause a detrimental effect (slower) on simple and choice response times.

2. Materials and Methods

2.1. Participants

A total of 16 healthy male and female participants successfully completed the study (age: 20 ± 1 years; height: 169.48 ± 8.2 cm; weight: 67.93 ± 12.7 kg; males: 5 and females: 11). The inclusion criteria consisted of both males and females being between 18–45 years of age and a physically active status based on the American College of Sports Medicine (ACSM) criteria for physical activity, which included a minimum of 3–5 days of aerobic exercise and 2 days of resistance training per week for at least the past 3 months and the completion of the physical activity readiness questionnaire (PAR-Q). The exclusion criteria consisted of the presence of any recent visual, vestibular, neurological, or musculoskeletal disorders. All participants read and signed the informed consent, approved by Mississippi State University's (Mississippi State, MS, USA) Institutional Review Board (IRB) under the protocol IRB# 21-320.

2.2. Instrumentation

Response times (RT) during both simple and choice response time tasks were delivered and assessed using BlazePod™ (BlazePod Inc., Miami, FL, USA), which included light emitting diode (LED) color lights producing pods that turn on randomly and turn off upon striking the pods. The BlazePod™ technology has been widely used by strength conditioning professionals, and more recently, the test–retest reliability of single leg striking the BlazePod™ task was tested and reported to have moderate to excellent levels of reliability [20] and also reported to have excellent reliability in agility tasks [21]. Additionally, the BlazePod™ smart application is a simple Bluetooth low energy (BLE) technology and is available for free for both Android and iOS users in comparison to other on-the-market response time trainer systems, which not only require proprietary tablet and software but are also expensive compared to the BlazePod™ systems. The noise interference used was an active construction site noise with heavy construction vehicles and power equipment that ranged from 65–85 dB and was provided by over-the-head noise cancellation headphones. Body weight acute exercises were used for inducing localized muscular workload with no specific exercise equipment.

2.3. Experimental Procedures

After signing the IRB-approved informed consent to participate in the study, all participant's anthropometry features of height, weight, leg length, and age were recorded. An initial familiarization session with the equipment was conducted, and participants performed 3–5 practice trials on the BlazePod™. Following this, participants were directed to be seated in a chair with no hand rests, and three BlazePods™ placed at an easy-to-reach distance from the right foot, based on each participant's leg length and subjective comfort of reaching the pods with their right lower extremity. Participants then performed three trials of the SRT task and the CRT task with no noise interference (No Noise), each taking 45 s. The SRT consisted of just one color (green) that randomly lit up in each of the three pods, which was then required to be struck by the participant, as quickly as possible, using their right leg. The CRT consisted of the same three pods; however, three different colors (green, blue, and red) lit up, and the participants were required to choose the green color pod and strike it as quickly as possible. The randomized lights coming on occurred continuously for 45 s for each trial. Upon completion of the initial SRT and CRT, participants were then provided noise cancellation headphones through which they listened to construction site noises at 65–85 dB, similar to the use of construction noises at 95 dB in the previous literature [17], and then repeated the three trials of SRT and three trials of CRT with noise interference (Noise) (Figure 1). Both SRT and CRT trials until then were treated as pre-workload (PRE). Following this, participants performed a physical workload task using three different types of bodyweight lower extremity fatiguing exercises. The three exercises consisted of three sets of ten unilateral body weight calf raises on both lower extremities, followed by three sets of 20 standard bilateral body weight squats, and finally, three sets of 20 standard body weight lunges, taking turns with both right and left lower extremities serving as the lead leg, to complete three sets for each lower extremity. All these exercises were performed within the laboratory space with no exercise equipment, instead using the participant's body weight. Immediately after this physical workload, participants once again completed three trials of 45 **s** each of the SRT and the CRT, both without noise interference and with noise interference (POST). This marked the completion of the experimental procedures. Similar pre-workload and post-workload testing methodologies have been previously implemented in cognitive–motor response studies that are similar to the current study [22,23] and other biomechanical assessments of trunk and postural stability [24,25].

Figure 1. Participant performing a choice response time (CRT) task with noise interference delivered through headphones.

2.4. Data and Statistical Analysis

RT from both SRT and CRT were recorded and analyzed using the BlazePod™ smartphone application. Response times in milliseconds (ms) from three trials of SRT and

CRT, both without and with noise interference, before and after the workload, were averaged correspondingly for statistical analyses. A 2 (Noise Interference (No Noise vs. Noise)) × 2 (Workload (PRE vs. POST)) × 2 (Task (SRT vs. CRT)) repeated measures analysis of variance (RM ANOVA) was performed to identify any significant differences between the independent variables of noise, workload, and task. Additionally, due to nature of SRT- and CRT-type tasks occurring in the real world, a 2 (Noise Interference (No Noise vs. Noise)) × 2 (Workload (PRE vs. POST)) repeated measures analysis of variance (RM ANOVA) was performed to identify any significant differences between the independent variables of noise and workload, individually and separately for SRT and CRT. If a significant interaction was found, main effects were ignored and simple effects were analyzed. For main effect significances, post-hoc pairwise comparisons were performed with a Bonferroni correction. All statistical analyses were performed using JASP (an open-source statistics program (University of Amsterdam, Amsterdam, The Netherlands) [26] at an alpha level of 0.05.

3. Results

The 2 × 2 × 2 RM ANOVA revealed a significant interaction ($p < 0.05$) between workload condition (PRE and POST) and task type (SRT and CRT) (F (1,15) = 4.989, $p = 0.041$, $\eta_p^2 = 0.250$). Post-hoc comparisons revealed that for the SRT task, response times were significantly lower (faster) during the POST-workload condition compared to the PRE workload (Figure 2). The RM ANOVA revealed significant main effect differences ($p < 0.05$) between No Noise and Noise (F (1,15) = 9.740, $p = 0.007$, $\eta_p^2 = 0.394$). Post-hoc pairwise comparisons revealed that response times were significantly lower (faster) during no-noise conditions compared to when exposed to noise (Figure 3). The RM ANOVA revealed significant main effect differences ($p < 0.05$) between workload conditions (F (1,15) = 4.814, $p = 0.044$, $\eta_p^2 = 0.243$). Post-hoc pairwise comparisons revealed that response times were significantly lower (faster) during the POST-workload condition compared to the PRE workload (Figure 3) (Table 1).

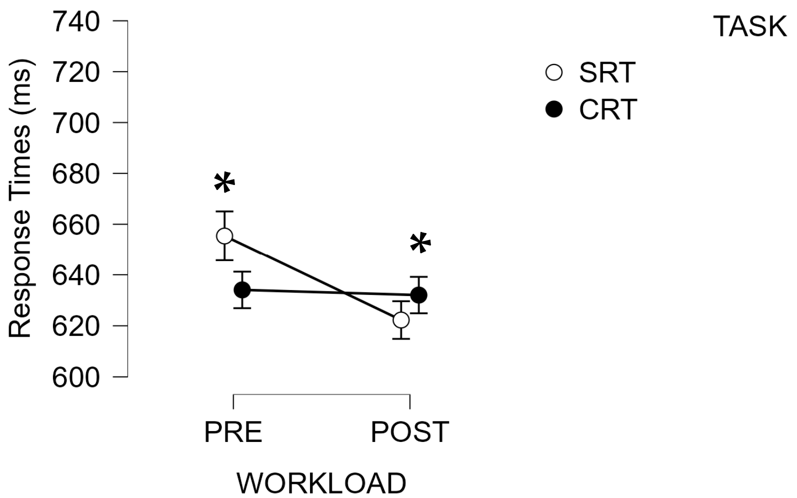

Figure 2. Response times (ms) during simple response time (SRT) and choice response time (CRT) tasks, before (PRE) and after (POST) the workload. * represents significant difference at $p < 0.05$, and bars represent standard errors.

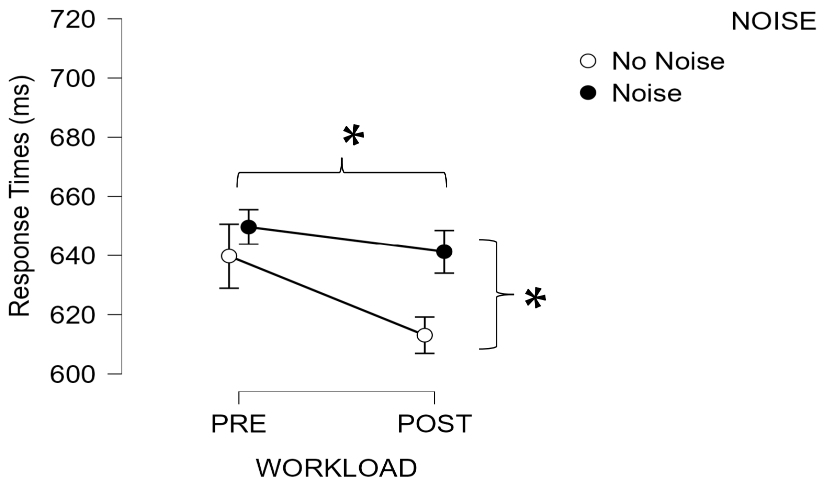

Figure 3. Response times (ms) of simple response time (SRT) and choice response time (CRT) tasks combined, without (No Noise) and with noise (Noise), before (PRE) and after (POST) the workload. * represents significant difference at $p < 0.05$, and bars represent standard errors.

Table 1. Noise × Workload × Task Repeated Measures ANOVA Table.

Independent Variables	F Statistic	*p* Value	η_p^2
Noise	F (1,15) = 9.74	0.007	0.394
Workload	F (1,15) = 4.814	0.044	0.243
Task	F (1,15) = 0.344	0.566	0.022
Noise × Workload	F (1,15) = 2.464	0.137	0.141
Noise × Task	F (1,15) = 0.279	0.605	0.018
Workload × Task	F (1,15) = 4.989	0.041	0.25
Noise × Workload × Task	F (1,15) = 3.365	0.087	0.183

The 2 × 2 RM ANOVA revealed significant main effect differences ($p < 0.05$) for both SRT and CRT. For SRT, significant main effect differences were seen between workload conditions (F (1,15) = 9.091, $p = 0.009$, $\eta_p^2 = 0.377$). Post-hoc pairwise comparisons revealed that POST-workload trials had a significantly faster response time compared to PRE-workload trials. There was not a significant main effect difference for noise interference or a significant interaction between noise interference and workload (Figure 4). For the CRT, significant main effect differences were seen between noise interference conditions (F (1, 15) = 14.139, $p = 0.002$, $\eta_p^2 = 0.485$). Post-hoc pairwise comparisons revealed that noise interference trials had a significantly slower response time compared to no noise interference trials. There was not a significant main effect difference for workload or a significant interaction between noise interference and workload (Figure 5) (Table 2). Descriptive statistics for both SRT and CRT response time measures under No-Noise–Noise and PRE- and POST-workload conditions are provided in Table 3. Finally, during all the SRT and CRT trials, none of the participants had any incorrect (error by hitting the wrong pod/lights) or missed Blazepod™ responses from an average response of around 20 per trial. Hence, the percentage of correct responses was 100%, and the percentage of missed responses was zero.

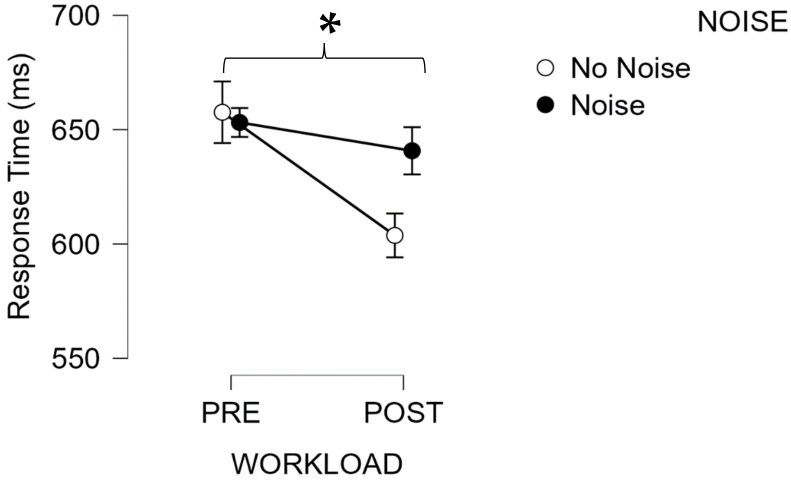

Figure 4. Response times (ms) during a simple response time (SRT) task, without (No Noise) and with noise (Noise), before (PRE) and after (POST) the workload. * represents significant difference at $p < 0.05$, and bars represent standard errors.

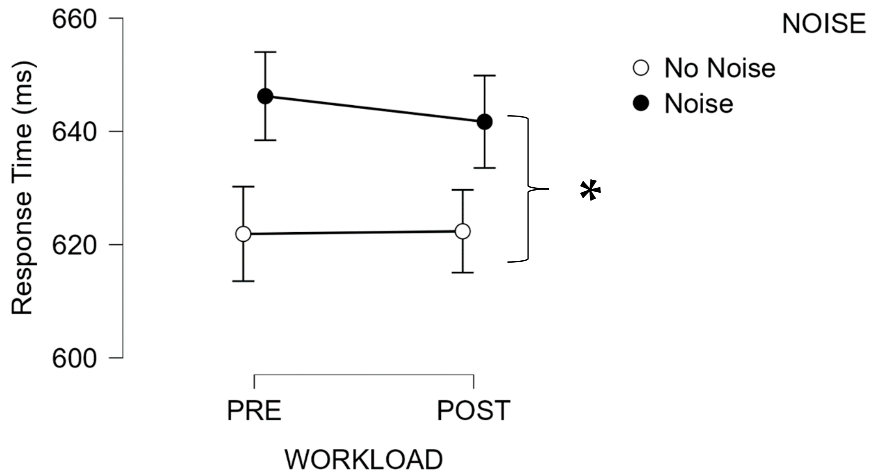

Figure 5. Response times (ms) during a choice response time (CRT) task, without (No Noise) and with noise (Noise), before (PRE) and after (POST) the workload. * represents significant difference at $p < 0.05$, and bars represent standard errors.

Table 2. Noise × Workload Repeated Measures ANOVA Table.

SRT			
Independent Variables	**F Statistic**	***p* value**	η_p^2
Noise	F (1,15) = 2.756	0.118	0.155
Workload	F (1,15) = 9.091	0.009	0.377
Noise × Workload	F (1,15) = 4.368	0.054	0.226
CRT			
Independent Variables	**F Statistic**	***p* value**	η_p^2
Noise	F (1,15) = 14.139	0.002	0.485
Workload	F (1,15) = 0.039	0.846	0.003
Noise × Workload	F (1,15) = 0.126	0.727	0.008

Table 3. Descriptive Statistics.

NOISE	WORKLOAD	TASK	Mean	SD	N
No Noise	PRE	SRT	657.606	89.354	16
		CRT	621.894	76.737	16
	POST	SRT	603.746	79.429	16
		CRT	622.361	73.547	16
Noise	PRE	SRT	653.145	76.122	16
		CRT	646.220	88.562	16
	POST	SRT	640.760	87.542	16
		CRT	641.701	73.405	16

4. Discussion

The purpose of the study was to investigate both the individual and combined effect of noise interference and a physical workload on lower extremity simple and choice response time tasks. Findings from the study indicated a significant interaction between the task type (SRT vs. CRT) and the workload condition (PRE vs. POST) with significantly faster response times in SRT during the POST-workload responses but not in CRT, suggesting a potential learning effect in the improvement of response times, rather than the hypothesized detrimental effect due to fatigue resulting from the workload. Additionally, the main effect of workload indicated that response times were significantly faster during POST-workload conditions, suggesting a potential learning effect, and the main effect for noise indicated that no noise conditions had significantly faster response times compared to the noise, suggesting that noise interference negatively impacts response times in a lower extremity cognitive–motor task. When SRT and CRT were analyzed individually, noise interference negatively impacted response time with statistically significantly slower response times in the CRT but without any statistically significant impact on the SRT. This suggests that when performing a relatively easier SRT task, individuals did not have significant interference due to the noise. However, when performing a more challenging CRT task, individuals were negatively impacted due to the noise interference, resulting in significantly slower response times which may be attributed to the decreased attention, increased need for effort, and changes in the choice of strategies for performed tasks due to noise interference [1,19]. Additionally, the findings also suggested that the workload used in this study did not negatively impact response times in both SRT and CRT. Individuals, however, demonstrated significantly faster response time in the POST trials but only during the SRT tasks, which may be attributed to a possible increase in physiological and cognitive arousal due to the exercise and a potential learning effect of the SRT task but not the CRT task [10]. Thus, the study's hypothesis of noise interference being detrimental to RT in a cognitive–motor task was upheld, but only in CRT, with demonstrated significant increase in RT. The hypothesis that workload is detrimental to RT in cognitive–motor tasks was not upheld and, in contrast, demonstrated a significant decrease in RT during POST. Additionally, the post-workload condition being always tested after the PRE-workload, always had more practice of the SRT and CRT tests, which may be a confounding factor, thereby contributing to an improvement of the response times due to potential learning effect and masking the potentially detrimental effect of muscular fatigue due to the workload. Finally, the current study also provides evidence that the lower extremity response times during cognitive–motor tasks demonstrated similar response time behavior observed with such upper extremity cognitive–motor tasks [10].

4.1. Noise Interference as a Predictor of Response Times

Findings from the study demonstrate that in a lower extremity cognitive–motor task, noise interference significantly affects response times, but only in a more complex CRT compared to a less complex SRT. The presence of noise causes an increase in response times (slower response times) that may be the result of physiological and/or psychological mechanisms [27]. The current findings support the previous literature where noise, both acute and continuous, has been reported to interfere with and negatively affect cognitive processing (that includes processes of sensation, perception, response selection, and processing) [19], vigilance, attention, and concentration [1] with an increase in human errors during task performance [14]. Additionally, the findings also support a similar previous study in which loud industrial and construction noise significantly increased the duration of reaction and movement times (slower reaction and movement times) during simple vigilant tasks [17]. Finally, an anxiety-induced reduction in cognitive performance due to noise exposure has also been suggested as a possible rationale for the increased and slower response times [17].

In the current study, noise exposure during an interference task paradigm with noise exposure, compared to a no-interference task paradigm without noise, caused a significant increase in response times. When the SRT and CRT tasks were combined in the analysis, the main effect for noise indicated that significantly slower response times were evident with exposure to noise. However, when the tasks were analyzed individually, this finding was only evident in a more complex CRT compared to SRT. In contrast to the above findings, there is also evidence that noise exposure does not impact reaction time or, in some cases, even demonstrates a decreased (faster) reaction time that is usually attributed to an increased arousal and stress level of the physiological or psychological mechanisms [1,12]. As such, in the current study, while noise exposure during the CRT induced significantly increased response times, the lesser complexity and the lower requirement of cognitive processing can be attributed to the non-significant differences in SRT response times. A short exposure of noise of low intensity (77 dB), medium intensity (81 dB), and high intensity (86 dB) were reported to not affect task performance reaction times, as evident from the results in the SRT, but caused subjective annoyance and discomfort [28]. In the SRT, noise exposure demonstrated an overall increased and slower response time in the POST-workload condition; however, this difference was not statistically significant. Differences in response times between PRE- and POST-workload conditions are discussed next under physical workload as a predictor of response times.

4.2. Physical Workload as a Predictor of Response Times

Findings from the current study demonstrate that in a lower extremity cognitive–motor task, the physical workload performed in the study did not cause a detrimental effect (slower response times) for SRT and CRT. In contrast, significantly lower (faster response times) were evident in SRT during the POST-workload condition, which was evident when the SRT and CRT tasks were analyzed together and individually. The previous literature on the impact of physical exercise or workload on cognitive performance demonstrates that there can be positive, negative, or neutral effects, but this is largely dependent upon the intensity and duration of the workload [10,29,30]. The finding from the current study not only supports the previous literature's assertion that cognitive performance is not affected by short-duration exercise [15], as evident from the results of CRT, but also supports that response times in a cognitive–motor task are decreased (faster response times) in response to exercise [10,29,31], which may be attributed to a possible increase in cognitive arousal due to exercise, as well as to the potential learning effect of the task [10] as evident from the results of SRT.

4.3. Limitations, Future Directions, and Applications

Several limitations of the current study include the testing of a healthy, young population who may have a lower impact due to noise and physical workload, whereas individuals with any neurological, auditory, or vestibular disorders or an elderly population may behave differently with noise and physical workload exposure [32]. Therefore, the observed results can only be generalized to the population tested. However, the healthy, young population tested in the study is commonly the population found in construction and industrial work sectors as an amateur workforce with less experience and with a potentially greater risk for occupational task errors and possible injuries. The study also did not assess any other physiological or subjective measures of noise or physical workload exposure and is limited to the response times as the outcome variable under no-interference and interference conditions and before and after workload. The study design of testing PRE-workload before the POST-workload conditions meant that the POST-workload testing always had greater practice than the PRE-workload testing, which could have a potential learning effect and, thereby, an improvement in the performance, which could have confounded the detrimental effect of the fatigue due to the workload. However, to minimize the learning effect, sufficient practice trials (15–20 trials) were provided during the familiarization session for both SRT and CRT conditions. While this study design might cause confounding effects, it is still commonly used in the previous literature [22–25]. However, appropriate caution is warranted when interpreting the findings. An additional limitation of the study included the placement position of the BlazePods™, as it was performed based on the leg length and comfort of the participant, which can impact the responses. However, with the focus of the study being noise and workload interference and the fact that in real-world conditions, occupational workers in similar scenarios requiring cognitive–motor tasks can adjust their posture and certain controls to customize their workstations, the BlazePod™ placement was not standardized. Future research should identify the impact of such positioning changes. Finally, the order of testing involved the SRT being performed ahead of the CRT. This order effect may be a confounding variable, which may have contributed to some learning effects, impacting the observed results. While the testing order was selected to test a simple task followed by a complex task, and sufficient practice trials for both SRT and CRT were provided for all participants during the familiarization session, future research should consider randomization of testing order to avoid confounding effects.

The current study tested the response times for a lower extremity cognitive–motor task involving light-based SRT and CRT, which are commonly conducted using upper extremity striking, hitting, or tapping tasks. Future research should focus more on lower extremity-based cognitive–motor tasks in a variety of real-world application tasks, such as driving. Additionally, future research focus should also be expanded onto memory-based tasks (short- and long-term), attentional capacity, arousal level, situational awareness, etc. The addition of subjective questionnaires to noise exposure, such as an anxiety questionnaire, can provide greater insights into noise interference and should be added in future studies. Simple physiological measures such as heart rate can also provide quantitative data for annoyance and anxiety due to noise exposure and should be added in future studies.

Noise and physical fatigue are common stressors in occupational environments but also in everyday outdoor environments, which can not only cause a significant burden to the health of the individuals but can also interfere with task performance, leading to errors, injuries, and a decrease in safety and productivity. The findings from this study can help further corroborate and understand these impacts, the impact of noise and physical workload, and the effect a combination of them has on simple and choice response times during no-interference and interference task paradigms. Findings can also be extrapolated to occupational cognitive–motor tasks such as driving a heavy machinery vehicle in accelerating and braking using the lower extremity as needed based on the environment, especially in the presence of the noise and lower extremity muscular fatigue that are common in occupational settings. Findings also emphasize the need for the appropriate selection and adoption of noise reduction measures, including wearing personal protective equipment (PPE) such as ear plugs and suitable scheduling of work–rest intervals. Finally, the study also provides evidence of response time behavior in lower extremity cognitive–motor tasks, which are more directly applied to cognitive–motor performance during driving road cars or job-specific heavy machinery vehicles.

5. Conclusions

The findings from the study suggested that noise interference negatively impacted response times in CRT but not in SRT. Additionally, response times were not affected due to the workload in CRT and improved in SRT. Thus, findings from the current study suggest that the impact of noise interruption is significant when the complexity of the response task is greater and that possible cognitive arousal due to the physical workload and potential learning effects may influence response time performances. However, the findings should be interpreted with caution due to the limitations of the study. Finally, a lower extremity cognitive–motor task demonstrated response time behavior similar to such upper extremity cognitive–motor tasks.

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Informed Consent Statement: Informed consent was obtained from all participants involved in the study who read and signed the consent form with the protocol IRB# 21-320.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Dalton, B.H.; Behm, D.G. Effects of Noise and Music on Human and Task Performance: A Systematic Review. *Occup. Ergon.* **2007**, *7*, 143–152. [CrossRef]
2. Fernández, M.D.; Quintana, S.; Chavarría, N.; Ballesteros, J.A. Noise Exposure of Workers of the Construction Sector. *Appl. Acoust.* **2009**, *70*, 753–760. [CrossRef]
3. Lie, A.; Skogstad, M.; Johannessen, H.A.; Tynes, T.; Mehlum, I.S.; Nordby, K.-C.; Engdahl, B.; Tambs, K. Occupational Noise Exposure and Hearing: A Systematic Review. *Int. Arch. Occup. Environ. Health* **2016**, *89*, 351–372. [CrossRef]
4. Arenas, J.P.; Suter, A.H. Comparison of Occupational Noise Legislation in the Americas: An Overview and Analysis. *Noise Health* **2014**, *16*, 306. [CrossRef]
5. Nelson, D.I.; Nelson, R.Y.; Concha-Barrientos, M.; Fingerhut, M. The Global Burden of Occupational Noise-Induced Hearing Loss. *Am. J. Ind. Med.* **2005**, *48*, 446–458. [CrossRef]
6. Belojevic, G.; Jakovljevic, B.; Slepcevic, V. Noise and Mental Performance: Personality Attributes and Noise Sensitivity. *Noise Health* **2003**, *6*, 77.
7. Thompson, R.; Smith, R.B.; Bou Karim, Y.; Shen, C.; Drummond, K.; Teng, C.; Toledano, M.B. Noise Pollution and Human Cognition: An Updated Systematic Review and Meta-Analysis of Recent Evidence. *Environ. Int.* **2022**, *158*, 106905. [CrossRef] [PubMed]
8. Passchier-Vermeer, W.; Passchier, W.F. Noise Exposure and Public Health. *Environ. Health Perspect.* **2000**, *108*, 123–131. [CrossRef]
9. Tzivian, L.; Winkler, A.; Dlugaj, M.; Schikowski, T.; Vossoughi, M.; Fuks, K.; Weinmayr, G.; Hoffmann, B. Effect of Long-Term Outdoor Air Pollution and Noise on Cognitive and Psychological Functions in Adults. *Int. J. Hyg. Environ. Health* **2015**, *218*, 1–11. [CrossRef]
10. Ellemberg, D.; St-Louis-Deschênes, M. The Effect of Acute Physical Exercise on Cognitive Function during Development. *Psychol. Sport Exerc.* **2010**, *11*, 122–126. [CrossRef]
11. Starosta, W.; Petryński, W. Selected Problems in International Terminology of the Human Movement Science. *Kinesiology* **2007**, *39*, 5–14.
12. Rossi, L.; Fardin, A.; Schiavi, A. Soft Metrology in Acoustics: Influence of Noise on Stroop Effect. In Proceedings of the AIA-DAGA Conference on Acoustics, Merano, Italy, 18–21 March 2013.
13. Chraif, M. The Effects of Radio Noise in Multiple Time Reaction Tasks for Young Students. *Procedia Soc. Behav. Sci.* **2012**, *33*, 1057–1062. [CrossRef]
14. Smith, A. Noise, Performance Efficiency and Safety. *Int. Arch. Occup. Environ. Health* **1990**, *62*, 1–5. [CrossRef] [PubMed]
15. Tsorbatzoudis, H.; Barkoukis, V.; Danis, A.; Grouios, G. Physical Exertion in Simple Reaction Time and Continuous Attention of Sport Participants. *Percept. Mot. Ski.* **1998**, *86*, 571–576. [CrossRef]
16. Cian, C.; Barraud, P.A.; Melin, B.; Raphel, C. Effects of Fluid Ingestion on Cognitive Function after Heat Stress or Exercise-Induced Dehydration. *Int. J. Psychophysiol.* **2001**, *42*, 243–251. [CrossRef]
17. Button, D.C.; Behm, D.G.; Holmes, M.; Mackinnon, S.N. Noise and Muscle Contraction Affecting Vigilance Task Performance. *Occup. Ergon.* **2004**, *4*, 157–171. [CrossRef]

18. Lorist, M.M.; Kernell, D.; Meijman, T.F.; Zijdewind, I. Motor Fatigue and Cognitive Task Performance in Humans. *J. Physiol.* **2002**, *545*, 313–319. [CrossRef]
19. Sharma, A.; Zheng, Z.; Kim, J.; Bhaskar, A.; Haque, M.M. Estimating and Comparing Response Times in Traditional and Connected Environments. *Transp. Res. Rec.* **2019**, *2673*, 674–684. [CrossRef]
20. de-Oliveira, L.A.; Matos, M.V.; Fernandes, I.G.S.; Nascimento, D.A.; da Silva-Grigoletto, M.E. Test-Retest Reliability of a Visual-Cognitive Technology (BlazePod TM) to Measure Response Time. *J. Sport. Sci. Med.* **2021**, *20*, 179–180. [CrossRef]
21. Hoffman, J.R. Evaluation of a Reactive Agility Assessment Device in Youth Football Players. *J. Strength Cond. Res.* **2020**, *34*, 3311–3315. [CrossRef]
22. Tavahomi, M.; Shanbehzadeh, S.; Abdollahi, I. Comparing the Effect of Fatigue on Choice Reaction Time of Healthy Men and Women. *Phys. Treat. Specif. Phys. Ther. J.* **2017**, *7*, 29–34. [CrossRef]
23. Hill, C.M.; DeBusk, H.; Simpson, J.D.; Miller, B.L.; Knight, A.C.; Garner, J.C.; Wade, C.; Chander, H. The Interaction of Cognitive Interference, Standing Surface, and Fatigue on Lower Extremity Muscle Activity. *Saf. Health Work.* **2019**, *10*, 321–326. [CrossRef] [PubMed]
24. Chander, H.; Garner, J.C.; Wade, C.; Wilson, S.J.; Turner, A.J.; Kodithuwakku Arachchige, S.N.K.; Hill, C.M.; DeBusk, H.; Simpson, J.D.; Miller, B.L.; et al. An Analysis of Postural Control Strategies in Various Types of Footwear with Varying Workloads. *Footwear Sci.* **2021**, *13*, 181–189. [CrossRef]
25. Allison, G.T.; Henry, S.M. The Influence of Fatigue on Trunk Muscle Responses to Sudden Arm Movements, a Pilot Study. *Clin. Biomech.* **2002**, *17*, 414–417. [CrossRef]
26. Love, J.; Selker, R.; Marsman, M.; Jamil, T.; Dropmann, D.; Verhagen, J.; Ly, A.; Gronau, Q.F.; Šmíra, M.; Epskamp, S.; et al. JASP: Graphical Statistical Software for Common Statistical Designs. *J. Stat. Softw.* **2019**, *88*, 1–17. [CrossRef]
27. Loeb, M.; Jeantheau, G. The Influence of Noxious Environmental Stimuli on Vigilance. *J. Appl. Psychol.* **1958**, *42*, 47–49. [CrossRef]
28. Ljungberg, J.; Neely, G.; Lundström, R. Cognitive Performance and Subjective Experience during Combined Exposures to Whole-Body Vibration and Noise. *Int. Arch. Occup. Environ. Health* **2004**, *77*, 217–221. [CrossRef]
29. Chang, Y.K.; Labban, J.D.; Gapin, J.I.; Etnier, J.L. The Effects of Acute Exercise on Cognitive Performance: A Meta-Analysis. *Brain Res.* **2012**, *1453*, 87–101. [CrossRef]
30. Lambourne, K.; Tomporowski, P. The Effect of Exercise-Induced Arousal on Cognitive Task Performance: A Meta-Regression Analysis. *Brain Res.* **2010**, *1341*, 12–24. [CrossRef]
31. McMorris, T.; Hale, B.J. Differential Effects of Differing Intensities of Acute Exercise on Speed and Accuracy of Cognition: A Meta-Analytical Investigation. *Brain Cogn.* **2012**, *80*, 338–351. [CrossRef]
32. Kodithuwakku Arachchige, S.N.K.; Chander, H.; Knight, A.C.; Burch, V.R.F.; Chen, C.-C.; Reneker, J.C. Dual Tasking during Trip Recovery and Obstacle Clearance among Young, Healthy Adults in Human Factors Research. *Int. J. Environ. Res. Public Health* **2021**, *18*, 10144. [CrossRef] [PubMed]