Available online at www.sciencedirect.com

ScienceDirect

IFAC PapersOnLine 59-10 (2025) 1820–1825

Human-centric manufacturing and occupational noise: A review regarding what we know and what we should know

Sajjad Shooshtari*, Matthias Klumpp*

**Politecnico di Milano, School of Management, Via Lambruschini 4B, 20156 Milan, Italy (e-mail: sajjad.shooshtari@polimi.it).*

Abstract: Although noise impacts on human well-being have been a topic for research and societies for a long time, empirical insights regarding the impact of occupational noise in manufacturing settings are surprisingly scarce. This paper provides a systematic review to outline the state-of-the-art in this segment and identify important and worthwhile fields for future research. Non-uniformity in effects was the dominant theme of the findings which could be related to the underexplored individuality and task-specificity features of the effects of occupational noise on humans. This is strongly connected to the concept of human-centric manufacturing as Industry 5.0 as the issue one dimension of human well-being and performance.

Keywords: Industry 5.0, human-centric manufacturing, occupational noise, workplace design, assembly performance.

1. INTRODUCTION

In industrial environments, workers are continuously exposed to environmental factors that influence their physical as well as cognitive condition, well-being, and overall performance (Broadbent, 1980). Among those, noise defined as any unwanted sound has been an issue for quite a long time: Environmental noise is increasingly prevalent due to urbanization and anthropogenic influences like factories and transportation; it poses various health risks, leading to regulations aimed at mitigating its effects (Asdrubali, 2014). Noise pollution impacts human health by causing hearing loss, sleep disruption, cardiovascular disease, reduced productivity, social handicaps, etc. (Karki et al., 2024). While laws and regulations on controlling noise exposure like EU directive 2003/10/EC, stipulating noise exposure limit values for workers or the corresponding US Occupational Safety and Health Standards subpart 1910 are in place in many countries, they follow the generalizing tendency of operations management. Though this might work for many operators, without some form of flexibility and consideration for individual characteristics, it is not inclusive and comes short for some others (Corbett, 2023). Furthermore, the perception of noise exposure as an unavoidable consequence of working in certain environments continues to contribute to the problem (Lie et al., 2015).

With the emergence of the Industry 5.0 – emphasizing a more human-centric approach – understanding more deeply how humans are affected by their working environment has become increasingly important from an additional angle (Breque et al., 2021). Despite the long-standing recognition of noise as a significant factor (Asdrubali, 2014), there is still limited understanding of its non-auditory effects, particularly on cognitive functions and performance. This systematic review presented here will try to answer the following question based on existing research:

> How does occupational noise exposure affect the arousal, attention, workload, and performance of human workers during manufacturing tasks?

2. SEARCH & REVIEW PROTOCOL

We followed a search and review protocol based on the PRISMA methodology. The eligibility criteria included: the study context should be industry, manufacturing, assembly, logistics, labs, or AR/VR and not medical, construction, restaurants, mines, offices, or hearing inspection settings. Only studies focusing on the performance, productivity, or error rate of workers or their cognitive workload, stress, attention, or arousal are included. Any noise intervention with a follow-up length of a maximum 8-hour work shift is considered. Using keywords relating to our eligibility criteria we performed our search on and Web of Science (WOS) on February 8, 2024. Lastly, only references in English are included. The following search string and the equivalent were respectively used in WOS and Scopus:

TS=((performance OR efficiency OR error OR attention OR arousal OR cognitive) AND noise AND (human OR worker) AND (industr OR occupation* OR assembly OR logistic* OR manufactur*)) NOT WC=(Medicine OR Biochemistry OR Pharmacology OR Immunology) AND LA=(English)*

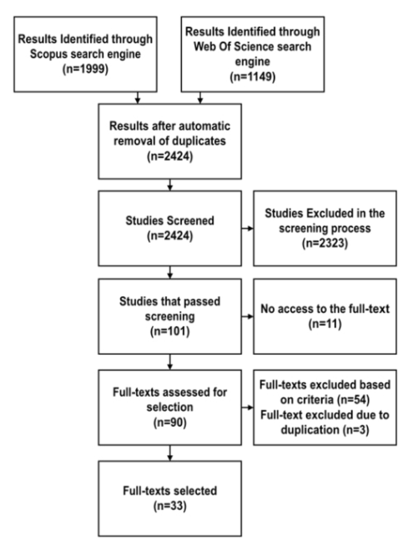

Figure 1. Systematic review process

We then screened the resulting references based on their titles, abstracts and keywords. The filtered references were then assessed based on their full texts. We looked for the

10.1016/j.ifacol.2025.09.306

following data items and outcomes in the full-texts: key study characteristics (study type, title, author, country, year), experimental details (setting, task type, participants, comparators, noise type and levels, exposure duration, measurement methods), and outcome measures related to stress, attention, arousal, workload, and performance. See Figure 1 for the review process flowchart.

3. REVIEW RESULTS

In this section, we separately report on findings regarding the connection of noise with arousal, attention, workload, stress and performance. Within each subsection, the results are divided into paragraphs based on the effects and noise types (positive, negative, non-uniform, neutral, and specific types of noise). Table 1 summarizes the review references.

3.1 Noise-effected arousal

Broadbent (1980) saw the noise as arousing, stimulating and exciting. But they argued these effects are not limited to noise, but to many other factors which all together form a general level of arousal. Rentzsch (1990) reported that skin resistance decreases more prominently for participants who experienced 90 dBA of noise exposure than those who experienced 60 dBA. [*Note:* Skin resistance can be considered as a metric of arousal (Albert & Tullis, 2023). Hence, we conclude that the arousal of their participants is increased by the increase of the sound pressure of the noise].

Kryter (1984) reports on many experiments and studies where arousal is discussed under the general idea that noise exposure might result in overarousal and hence reduction of performance. The reported studies are not all in agreement on this notion. Some show positive, some show negative, and some show no effect of noise exposure on participants. They believed statistically significant repeated results were not present in any aspects regarding the non-auditory effects of noise. Berglund et al. (1996) mention that the effect of noise on arousal is complex and unclear in direction. They mention that people who suffer from low-frequency noise (hurt more by it) are more prone to showing changes in heart rate when they are exposed to low-frequency noise.

Wheale & O'Shea (1982) measured the heart rate of the participants as an arousal metric. They observed no increase in heart rate due to exposure to different noise conditions.

In total, it appears that studies that regard noise-effected arousal, do not show a clear conclusion on how noise affects arousal. Signs of changes in the level of arousal could be observed in some studies, yet they are not conclusive. It is worth mentioning that none of the studies explicitly mentions reduction of arousal due to noise exposure.

3.2 Noise-effected attention

Zeydabadi et al. (2019) used a visual attention test to measure selective attention score, divided attention score, selective response time, and divided response time. For workers who were exposed to noise, a significant reduction of the 2 direct attention metrics and an increase of the 2 response time metrics were observed. Furthermore, between low exposure and high exposure groups, a significant reduction of divided attention score and a significant increase in selective response time, and divided response time were observed by the increase of noise levels. Caporale et al. (2022) state that noise exposure in the work environment reduces concentration abilities. Golmohammadi et al. (2022) observed that by the increase of noise, cognitive processes (incl. attention) were reduced.

Smagowska (2010) reports results that suggest 104 dBA of high-frequency noise exposure increased the attention metric of participants during the exposure but left them with shorter attention spans after the exposure. But for the 97 dBA, only a significantly higher attention metric during exposure could be observed. Zhou et al. (2023) considered 13 attention tasks. Out of those, 10 showed no significant impacts due to noise exposure, 2 showed deterioration impacts and 1 showed positive impact.

Sousa et al. (2019) used serial recall and response inhibition tests as metrics of attention, observing no differences in terms of attention metrics between testing conditions.

Wheale & O'Shea (1982) used a self-reported attention span metric. Several of their participants found intermittent noise the most distracting. Cho et al. (2011) report on Alpha band activity of the brain during noise exposure. They observed smaller Alpha activity when the participants were exposed to 100Hz and 10,000Hz frequencies [*Note:* Lower Alpha band activity can be related to alpha suppression which is an indicator of increased attention (Knyazeva, 2021). Therefore, we can interpret their findings as the increase of attention when exposed to 100Hz and 10,000Hz with respect to pre-exposure]. Ghasemi et al. (2022) consider pink noise to improve the status of attention and focus. They deem it proper for high cognitive needs jobs, providing a similar review of white noise with weaker effects. Ghasemi et al. (2023) state that white noise may be used to increase attention and concentration, adding white noise might reduce distractions and increase attention via its masking effects.

The effects of noise on attention seem to be widespread. Negative, neutral effects of noise loudness on attention, during and after noise exposure can be inferred from this review, various types of noise show diverse attention effects.

3.3 Noise-effected workload

Rentzsch (1990) reported psychological effort in 90dBA to be higher than in 60dBA. An et al. (2022) incorporated Borg C-10 to measure the mental workload of their participants. They showed exposure to the noise conditions increased the mental workload. Manghisi et al. (2022) used Noise-TLX to measure the workload perceived by the participants due to noise. They observed that the level of perceived cognitive workload increased significantly with the increase in noise.

Gabbard et al. (2017) considered prefrontal cortex (PFC) activation as a sign of mental workload. The result of their analysis does not fully support their hypothesis that PFC activity should increase due to noise exposure. Concerning noise-induced mental workload and by extension workload, literature seems to mostly agree that the perceived mental workload increases with an increase in sound pressure levels. The only study which does not agree with this result is Gabbard et al. (2017) which used the physiological response of the body as PFC to measure mental workload.

Table 1. Review References

Reference	Context	Task/Job	Participants [age]	Relevant Noise Conditions
(Abbasi et al., 2020)	Textile industry	Office staff, technicians, or workers in weaving or spinning	183 workers [average 39.7]	Unspecified duration of industrial noise at 68.5dBA, 81.1dBA, 92.5dBA, and 94.5dBA vs wearing ear protection
(An et al., 2022)	Lab experiments	Corsi block-tapping, Digit span, and 3-back tasks	30 persons	Unspecified duration of manufacturing and construction noise at 80dBA and 40-45dBA
(Beaman, 2005)	Review article	N/A	N/A	N/A
(Berglund et al., 1996)	Review article	N/A	N/A	Low-frequency noise
(Broadbent, 1980)	Review article	N/A	N/A	N/A
(Capistrano & Norona, 2020)	Electrical equipment industry	Operators, helpers and supervisory staff	31 persons	Unspecified duration of varying noise levels from 95dBA to 114dBA
(Caporale et al., 2022)	Review article	N/A	N/A	N/A
(Cho et al., 2011)	Lab experiments	No experimental task	15 males [25,30]	5 minutes of low (100 Hz), middle (1,000 Hz), and high frequency (10,000 Hz) at 70dBA
(Davies & Davies, 1975)	Lab experiments	Cancellation task and continuous performance task	40 males [18,31] and 40 males [65,72]	21 minutes of white noise at 70 dBA and 95 dBA
(Fathurrahman et al., 2019)	Metal production industry	Cutting block operations and cross-cutting machine operations	Unspecified	Unspecified duration of noise at 106.3dBA, 94.2dBA and 71.3dBA and 74.2 dBA wearing ear protection
(Gabbard et al., 2017)	Lab experiments	Anomaly detection in video	3 females and 7 males	Varying duration of environmental noise at 70dBA
(Ghasemi et al., 2022)	Review article	N/A	N/A	N/A
(Ghasemi et al., 2023)	Review article	N/A	N/A	N/A
(Golmohammadi et al., 2022)	Closed offices, Open-plan offices, Control rooms, Industrial workplaces, and Lab experiments	Unspecified	31 Males for each setting	8-hour shifts at 73dBA in control rooms and at 80dBA in the industrial settings
(Jerison, 1959)	Lab experiments	Monitoring a panel of three Mackworth-type clocks and counting lights flashes	Volunteer males	Unspecified duration of 114 dBA vs 83 dBA and 111.5 dBA vs 77.5 dBA
(Kryter & Poza, 1980)	Lab experiments	Psychomotor tasks	6 males	8 minutes of computer line printer sounds at 50dBA and 100dBA
(Kryter, 1984)	Review book	N/A	N/A	N/A
(Levyleboyer, 1989)	Automotive industry	Carburetors and air conditioners assembly	94 workers	Unspecified duration of the contextual noise at 75dBA, 90dBA and 62dBA
(Manghisi et al., 2022)	Virtual reality	N-back test with two difficulty levels	16 males and 8 females [23,51]	Unspecified duration pressure washer noise at 50dBA, 70dBA, and 85dBA
(Mir et al., 2022)	Lab experiments	No experimental task	18 males and 5 females [20,46]	3 minutes of construction, jackhammer, pile driver and bulldozer noise at 55dBA, 65dBA, 75dBA, and 85dBA
(Mucci et al., 2021)	Review article	N/A	N/A	N/A
(Muzammil & Hasan, 2004)	Lab experiments	Operation of Lathe machine, power press, polishing machine, grinders, hand press etc.	10 males [22,30]	60 minutes of continuous and intermittent noise at 90dBA, 95dBA, 100dBA and 105dBA
(Muzammil et al., 2011)	Lab experiments	Lock manufacturing	9 males [17,35]	Unspecified duration of noise at 80dBA, 90dBA, and 100dBA
(Noweir, 1984)	Textile industry	Unspecified	2458 male workers	Unspecified duration of >90 dBA vs <90 dBA of the contextual noise
(Pawlaczyk-Łuszczyńska et al., 2005)	Lab experiments	Signal detection test, the Stroop color-word test, math reasoning test, and comparing of names test	191 males	Unspecified duration of Broadband and low frequency noise at 50dBA and background laboratory noise at 30dBA
(Rentzsch, 1990)	Lab experiments and unspecified industry	Micro assembly with high visual requirement, process monitoring, and process supervision	Males and females	18 hours of 65dBA, 70dBA, 75dBA 3 hours of 50dBA, 60dBA, 70dBA 3 hours of 65dBA, 75dBA 50 minutes of 60dBA and 90dBA
(Ryherd & Wang, 2008)	Lab experiments	Verbal portion of the Graduate Record Examination (GRE) test.	15 males and 15 females	55 minutes of noise at 47dBA with different tonal components
(Smagowska, 2010)	Lab experiments	ALS – work efficiency test, DAUF – continuous attention test	20 persons [25,30]	Unspecified duration of Ultrasonic noise at 97dBA and 140dBA and the computer working noise
(Sousa et al., 2019)	Lab experiments	Serial recall and response inhibition tests	8 males, 8 females	Unspecified duration of industrial and 500Hz alert noise at 45dBA and industrial and 1000Hz, 2000Hz and 3000Hz alert noise at 68dBA
(Taylor et al., 2004)	Lab experiments	Visual inspection	15 persons [21,28]	Unspecified duration of intermittent noise, continuous noise, and random noise at 80dBA from single or multiple sources and 40dBA of ambient noise
(Wheale & O'Shea, 1982)	Lab experiments	4 choice psychomotor task	20 males [19,39]	8 minutes of approximately 100 dBA of Teletype printer, intermittent, jet cockpit, helicopter cockpit noise vs 66 dBA of White noise
(Zeydabadi et al., 2019)	Metal industry	Pressure forging, extrusion, machining, grinding, and packaging, warehouse and quality control as control group	164 workers	Unspecified duration of noise >90 dBA and at 85 to 90dBA
(Zhou et al., 2023)	Review article	N/A	N/A	N/A

3.4 Noise-effected stress

Rentzsch (1990) used Electrocardiogram and Electrodermal Activity to measure the stress, arousal, and workload of the participants. In a monitoring task, they observed an exponential-like relation between sound pressure levels and stress levels. Abbasi et al. (2020) used surveys to measure job stress and noise sensitivity. They found noise exposure to increase job stress. It could also be observed that noise sensitivity works as a mediator in this relation. Golmohammadi et al. (2022) used salivary cortisol and electro-dermal activity as measures of stress. They found increasing levels of noise exposure to significantly increase stress. They also found time to play an amplifying factor for electrodermal activity. Mir et al. (2022) used a single-item self-reported metric of stress. They found significantly higher stress levels for higher sound pressure levels.

Kryter & Poza (1980) measured pulse amplitude and peripheral blood volume as metrics of stress. They observed no increase in physiological stress in different noise conditions.

Cho et al. (2011) used the Electroencephalogram's Beta band and eye-tracking pupil response time to measure stress. Their analysis showed that stress levels are higher in 100Hz and 10,000Hz than in 1000Hz. Sousa et al. (2019) used surveys to assess the stress levels of participants in their experimental conditions. They showed that with the increase in frequency, stress levels increase.

Studies in the literature regarding noise-induced stress are more inclined towards an increase in stress with an increase in sound pressure levels. 4 out of 5 discussed studies support this notion. In terms of frequency, the result is not as clear. It could be understood that high frequencies result in higher stress levels. Yet in terms of low (100-500Hz) and mid frequencies (1000Hz), the results of the two studies which discuss this issue do not match.

3.5 Noise-effected performance

Jerison (1959) found noise exposure might degrade performance in terms of time but only after a lengthy period of exposure, i.e., 1.5 hours. They count boredom and fatigue as interacting factors with noise exposure that result in this degradation. They also cited a higher error rate due to noise exposure.

Rentzsch (1990) reports that in visual checking, the reduction of performance is significant in noisy conditions but the error rate remained unchanged. In monitoring at 75dBA, omissions increased with respect to 65dBA. Muzammil & Hasan (2004) found in an easy task setting, random and intermittent noise patterns increased error rates. Muzammil et al. (2011) found the increase in noise resulted in a decrease in productivity regardless of the age group of the participants. Fathurrahman et al. (2019) recorded an increase in productivity and a decrease in error rates of the operators after wearing hearing protection. Capistrano & Norona (2020) found a significant negative correlation between noise exposure and productivity. An et al. (2022) mention performance if requires processing by the phonological loop, is deuterated in noisy conditions. Caporale et al. (2022) mention that only extreme noise annoyance reduces productivity. Golmohammadi et al. (2022) found productivity to be better in 55dBA in their lab settings and 55-65dBA in the industrial setting.

Davies & Davies (1975) observed that the productivity of older subjects was significantly enhanced by noise, while the younger subjects were not significantly affected by it. They also realized that noise exposure might reduce error rates in older people. In general, their result points out that in noisy conditions, the trade-off of productivity-accuracy weighs more towards productivity. Kryter (1984) states that noise may affect performance positively, negatively, or not affect it. They believe that meaningless noise will be adapted to by its repetition and will lose its possible effects over time. They also cite that noise sensitivity as perceived by subjects does not strongly correlate with the physiological response of subjects to noise. Noweir (1984) found the mean production efficiency to be significantly higher for the low-noise group. Amongst younger workers, they found the mean production efficiency to be higher in the higher noise conditions. Levyleboyer (1989) observed that in noisy conditions, the performance was improved in one and distorted in another task. They also realized that error rates significantly increased in noisy conditions. Berglund et al. (1996) mention that noise clearly affects performance but this effect is usually inconsistent and in interaction with other factors. These factors could be time of day, arousal, gender, task speed, accuracy, individual cultural factors, attitude to noise, noise sensitivity, etc. Beaman (2005) notes irrelevant speech to improve the cognitive performance of 10% of people in short-term memory. They also note that 20% of people are not affected by noise distractions. Mucci et al. (2021) state the relation between noise level and productivity is not clear and different studies have found opposing results. This might be due to interaction with other factors such as individual sensitivity and coping strategies. Zhou et al. (2023) tested overall 84 tasks: 17 of those were negatively affected by noise, 9 were positively affected and 58 were not affected by noise [*Note:* This result emphasizes how non-auditory effects of noise are task related].

Kryter & Poza (1980) found no significant differences in performance between their noise conditions. Furthermore, their subjects did not perceive the task more difficult in any of the conditions. Ryherd & Wang (2008) found no significant changes in task performance due to noise conditions. Smagowska (2010) found psychomotor performance unaffected by noise exposure. They found exposure to high-frequency noise increased the performance with respect to the comparator condition. Gabbard et al. (2017) observed no significant change in reaction time and performance due to noise conditions.

Wheale & O'Shea (1982) realized none of their noise conditions caused significant detrition of productivity. The sounds relating to helicopter and jet noise improved the performance of their subjects and the intermittent noise increased the error rate. Taylor et al. (2004) found in an easy task setting, random and intermittent noise patterns increased error rates. Their results suggest some improvement of performance in single source noise conditions over no noise and multiple source conditions. Pawlaczyk-Łuszczyńska et al.

(2005) noted no significant difference in performance due to low-frequency noise (LFN) exposure. Ghasemi et al. (2023) found white noise exposure increases the performance of activities which include sequential short-term memory.

Concerning performance, the results are widely dispersed. Many studies show non-uniform or insignificant changes in performance due to increasing noise intensity while many others show negative effects of noise intensity on performance. In terms of noise type, low-frequency noise seems to not affect average performance while high-frequency noise increased average productivity in a study. Intermittent noise is the type that has been discussed commonly in the literature, yet its effects do not seem to be fully determinable. White noise possibly due to its masking effects, has been discussed as a noise which may increase productivity.

4. DISCUSSION

Due to the variation in the findings of different studies, almost none of the discussed effects of noise could be concluded in a simple one-directional impact. Here, we discuss the reasons and the implications of this non-uniform relation.

Most previous reviews have mentioned individuality differences as affecting factors in the non-auditory effects of noise. Some studies showed that age is not an effecting factor, yet others consider it as a predictive factor. Interestingly, one study found perceived noise sensitivity to be not strongly correlated with the impacts of noise. Given this understanding that non-auditory effects of noise are person-specific, there are no studies in our review which consider individuality differences in their modelling. All studies have focused on finding one or a few estimations of the effects of noise on the average person. An approach which seems to be inherently wrong in this subject.

Furthermore, we observe that studies which have used multiple settings with similar noise conditions have found varying results depending on the settings. We can understand that the effects of noise are extremely task-related. In such situations, trying to find industry-wide or extendable implications relating to the effects of noise is bound to fail.

Given these person and task-specificities, we believe, the topic currently needs a more extendable modelling which considers differences in people and tasks. An example of such modelling approaches is provided by Gabellini et al. (2024) who used a hybrid modelling approach considering worker fatigue and learning. Another example of profound modelling with worker difference consideration is presented by Loske et al. (2024) where mixed effect modelling has been used to account for picking performance of workers considering their first writing direction. In practice, should this modelling be anything less than considering all possible effecting factors on humans in all settings, we may again find ourselves surrounded by confused or inconsistent results. Alternatively, it seems more operationally feasible to look for a straightforward and widely applicable methodology that can measure the effects of noise and model them with considerations for person and task-specificities in different scenarios, see Figure 2 for an example.

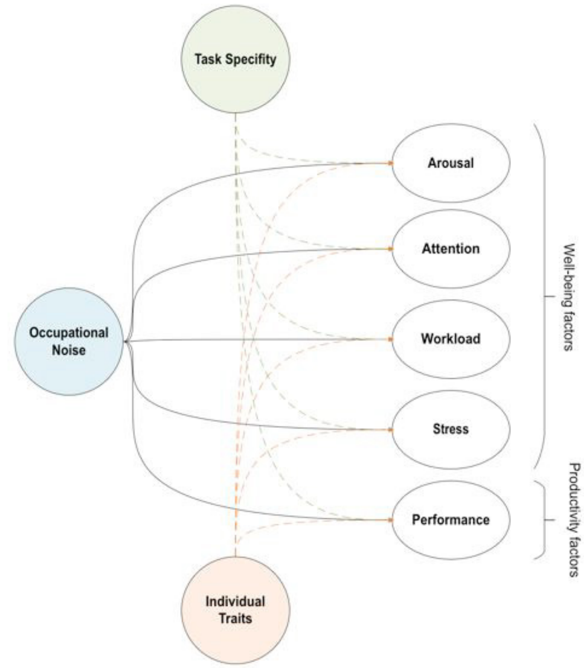

Figure 2. Non-auditory effects of noise design model

5. CONCLUSIONS

This review highlights the complex non-auditory effects of noise in manufacturing. Our findings highlight how these effects are highly individualized and task-specific, suggesting that broad generalizing approaches are unlikely to succeed. By acknowledging the unique needs of the workers about noise management in manufacturing, this study contributes to the human-centric paradigm of Industry 5.0. We strongly believe that future research on this topic should consider workers' uniqueness more profoundly and more practically.

REFERENCES

Abbasi, M., Yazdanirad, S., Mehri, A., Fallah Madvari, R., Alizadeh, A., Ghaljahi, M., & Falahati, M. (2020). Noise Exposure and Job Stress - a Structural Equation Model in Textile Industries. *Archives of Acoustics*, 45(4), 601–611.

Albert, W.B, & Tullis, T. S. (2023). *Measuring the User Experience (3rd Edition),* Chapter 8 - Measuring Emotion. Morgan Kaufmann, United States.

An, S., Kim, K., Ahn, D., Lee, H., Son, M., & Beck, D. (2022). Effects of Auditory Pre-Stimulation on Cognitive Task Performance in a Noisy Environment. *Applied Sciences*, 12(12).

Asdrubali, F. (2014). New frontiers in environmental noise research. *Noise Mapping*, 1(1), 1–2.

Beaman, C. P. (2005). Auditory distraction from low-intensity noise: A review of the consequences for learning and workplace environments. *Applied Cognitive Psychology*, 19(8), 1041–1064.

Berglund, B., Hassmen, P., & Job, R. F. S. (1996). Sources and effects of low-frequency noise. *Journal of The Acoustical Society of America*, 99(5), 2985–3002.

Boyce, P. R. (2014). *Human Factors in Lighting (3rd Edition)*, CRC Press, United States.

Breque, M., De Nul, L., & Petridis, A. (2021). Industry 5.0 – Towards a sustainable, human-centric and resilient European industry. *Publications Office of the European Union.*

Broadbent, D. E. (1980). Noise in relation to annoyance, performance, and mental health. *Journal of the Acoustical Society of America*, 68(1), 15–17.

Capistrano, R. C. P., & Norona, M. I. (2020). Workplace Design Improvement for Cable Tray Production in an Electrical

Equipment Company: A Lean Perspective. *Proceedings of the 2020 2nd International Conference on Management Science and Industrial Engineering,* 97-104.

Caporale, A., Botti, L., Galizia, F. G., & Mora, C. (2022). Assessing the impact of environmental quality factors on the industrial performance of aged workers: A literature review. *Safety Science*, 149.

Cho, W., Hwang, S.-H., & Choi, H. (2011). An investigation of the influences of noise on EEG power bands and visual cognitive responses for human-oriented product design. *Journal of Mechanical Science and Technology*, 25(3), 821–826.

Corbett, C. J. (2023). OM Forum—The Operations of Well-Being: An Operational Take on Happiness, Equity, and Sustainability, *Manufacturing & Service Operations Management,* 26(2), 409–430.

Davies, A. D. M., & Davies, D. B. (1975). The Effects of Noise and Time of Day upon Age Differences in Performance at Two Checking Tasks. *Ergonomics*, 18(3), 321–336.

Fathurrahman, L., Prasnowo, M. A., Rodli, A. F., & Makki, A. (2019). Analysis of noise effects on defect levels and work productivity at PT. Industrimarmer indonesia (IMI). *International Journal of Innovation, Creativity and Change*, 9(12), 13–23.

Fisk, W. J. (2000). Health and productivity gains from better indoor environments and their relationship with building energy efficiency. *Annual Review of Energy and the Environment*, 25, 537–566.

Gabbard, R., Fendley, M., Dar, I. A., Warren, R., & Kashou, N. H. (2017). Utilizing functional near-infrared spectroscopy for prediction of cognitive workload in noisy work environments. *Neurophotonics*, 4(4).

Gabellini, M., Calabrese, F., Regattieri, A., Loske, D., & Klumpp, M. (2024). A hybrid approach integrating genetic algorithm and machine learning to solve the order picking batch assignment problem considering learning and fatigue of pickers. *Computers & Industrial Engineering*, 191.

Ghasemi, S., Fasih-Ramandi, F., Monazzam, M. R., & Khodakarim, S. (2023). White Noise and Its Potential Applications in Occupational Health: A Review. *Iranian Journal of Public Health*, 52(3), 488–499.

Ghasemi, S., Fasih-Ramandi, F., Monazzam-Esmaeelpour, M. R., & Ardakani, S. K. (2022). Different Colors of Noise and Their Application in Psychoacoustics: A Review Study. *Journal of Health And Safety At Work*, 12(3), 459–482.

Golmohammadi, R., Darvishi, E., Shafiee Motlagh, M., Faradmal, J., Aliabadi, M., & Rodrigues, M. A. (2022). Prediction of occupational exposure limits for noise-induced non-auditory effects. *Applied Ergonomics*, 99.

Jerison, H. J. (1959). Effects of noise on human performance. *Journal of Applied Psychology*, 43(2), 96–101.

Karki, T. B., Manandhar, R. B., Neupane, D., Mahat, D., & Ban, P. (2024). Critical Analysis of Noise Pollution and Its Effect on Human Health. *International Journal of Educational and Life Sciences*, 2(2), 161–176.

Knyazeva, M. G. (2021). Alpha rhythms: what they are and how they alter with aging. Martin, C.R, Preedy & V.R, Rajendram, R. (ed.) *Factors Affecting Neurological Aging: Genetics, Neurology, Behavior, and Diet*, 349–359. Academic Press, United States.

Kryter, K. D. (1984). *Physiological, psychological, and social effects of noise. NASA Reference Publication*.

Kryter, K. D., & Poza, F. (1980). Autonomic system activity and performance on a psychomotor task in noise. *Journal of the Acoustical Society of America*, 67(6), 2096–2098.

Lan, L., Lian, Z., & Pan, L. (2010). The effects of air temperature on office workers' well-being, workload and productivity-evaluated with subjective ratings. *Applied Ergonomics*, 42(1), 29–36.

Levyleboyer, C. (1989). Noise effects on two industrial tasks. *Work and Stress*, 3(4), 315–322.

Lie, A., Skogstad, M., Johannessen, H. A., Tynes, T., Mehlum, I. S., Nordby, K. C., Engdahl, B., & Tambs, K. (2015). Occupational noise exposure and hearing: a systematic review. *International Archives of Occupational and Environmental Health*, 89(3), 351–372.

Loske, D., Klumpp, M., De Vries, J., Bührmann, A. D., Giese, J., & Lübke, J. (2024). The Impact of Writing Direction on Order-Picking Performance: Evidence on Diversity and Efficiency in Operations Management. *Production and Operations Management,* 0(0).

Manghisi, V. M., Martellotta, F., Evangelista, A., Giliberti, C., Mariconte, R., Diano, M., Galasso, V., & Uva, A. E. (2022). Investigating the Effects on User Performance and Perceived Workload of Environmental Noise in Immersive Virtual Reality. *2022 IEEE International Workshop on Metrology for Extended Reality, Artificial Intelligence and Neural Engineering, MetroXRAINE 2022 - Proceedings*, 46–51.

Mir, M., Nasirzadeh, F., Bereznicki, H., Enticott, P., & Lee, S. H. Y. (2022). Investigating the effects of different levels and types of construction noise on emotions using EEG data. *Building And Environment*, 225.

Mucci, N., Traversini, V., Lulli, L. G., Vimercati, L., Rapisarda, V., Galea, R. P., De Sio, S., & Arcangeli, G. (2021). Neurobehavioral alterations in occupational noise exposure: A systematic review. *Sustainability*, 13(21).

Muzammil, M., Ahmad, S., Khan, A. A., & Hasan, F. (2011). Design of a workstation and its evaluation under the influence of noise and illumination for an assembly task. *Work-A Journal of Prevention Assessment & Rehabilitation*, 39(1), 3–14.

Muzammil, M., & Hasan, F. (2004). Human performance under the impact of continuous and intermittent noise in a manual machining task. *Noise and Vibration Worldwide*, 35(7), 10–15.

Noweir, M. H. (1984). Noise exposure as related to productivity, disciplinary actions, absenteeism, and accidents among textile workers. *Journal of Safety Research*, 15(4), 163–174.

Pawlaczyk-Łuszczyńska, M., Dudarewicz, A., Waszkowska, M., Szymczak, W., Kameduła, M., & Śliwińska-Kowalska, M. (2005). Does low frequency noise at modarate levels influence human mental performance? *Journal of Low Frequency Noise Vibration and Active Control*, 24(1), 25–42.

Rentzsch, M. (1990). Interactions between different types of industrial noises and work tasks. *Environment International*, 16(4–6), 459–470.

Ryherd, E. E., & Wang, L. M. (2008). Implications of human performance and perception under tonal noise conditions on indoor noise criteria. *Journal of the Acoustical Society of America*, 124(1), 218–226.

Smagowska, B. (2010). Laboratory tests of the influence of ultrasonic noise on the human in the frequency range 10 KHZ - 40 KHZ. *39th International Congress on Noise Control Engineering,* 8, 6583–6592.

Sousa, J., Monteiro, R., Tomé, D., & Rodrigues, M. A. (2019). Effects of noise frequency on performance and well-being. Arezes,P.M, Melo, R.B, Carneiro, P., Branco, J.C, Colim, A., Costa, N., Costa, S., Duarte, J., Guedes, J.C, Perestrelo, G. & Santos Baptista, J. (ed.), Occupational and Environmental Safety and Health, 521–528, Springer Cham, Switzerland

Taylor, W., Melloy, B., Dharwada, P., Gramopadhye, A., & Toler, J. (2004). The effects of static multiple sources of noise on the visual search component of human inspection. *International Journal of Industrial Ergonomics*, 34(3), 195–207.

Wheale, J. L., & O'Shea, N. M. (1982). Noise and the performance of a four-choice psychomotor task. *Ergonomics*, 25(11), 1053–1064.

Zeydabadi, A., Askari, J., Vakili, M., Mirmohammadi, S. J., Ghovveh, M. A., & Mehrparvar, A. H. (2019). The effect of industrial noise exposure on attention, reaction time, and memory. *International Archives of Occupational and Environmental Health*, 92(1), 111–116.

Zhou, H., Molesworth, B. R. C., Burgess, M., & Hatfield, J. (2023). The effect of moderate broadband noise on cognitive performance: a systematic review. *Cognition, Technology and Work*, 26(1), 1-36.