

## Cognitive Ergonomics in the Aging Workforce: A Contemporary Health and Safety Perspective

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### ABSTRACT

This study examines the overlap between cognitive ergonomics and aging workforce processes, establishing interventions on how workplaces can be designed to offer the best-in-class working arrangement and safety measures. It compiles literature on cognitive aging, occupational hazards, and ergonomic worksite interventions on older workers on topics associated with cognitive aging, including processing speed, memory, and decision-making. The analysis of 13 peer-reviewed articles (2016-2025) reveals that specific ergonomic measures, such as optimized interface, improved light sources, and adaptive technologies, can eliminate cognitive deteriorations. Companies using such strategies witness 35 % fewer incidents, 28% job satisfaction, and 42% improved productivity among employees 55+. This research provides evidence-based outcomes on establishing age-inclusive work environments, which are valuable in building the future of managing multigenerational workforces

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## INTRODUCTION

The modern workplace is undergoing a demographic revolution with people across the globe growing old and life spans before retirement increasing. The increase of the proportion of the 55+ age group as a part of the global labor force will reach about 35% by 2030, which is a substantial imbalance in the traditional distribution of ages (Jane Osareme et al., 2024). Such demographic change is associated with both opportunity and challenge to occupational health and safety personnel who must change the workplace environment to meet the unique requirements of an aging workforce and ensure that they are productive and healthy.

Cognitive ergonomics has been explained as a scientific discipline linked to the study of human cognitive capacities, processes, and how they interrelate with work systems. It has now become a critical field necessary to reduce the problem of age in workplaces (Fisher et al., 2017). Unlike traditional ergonomics, a human endeavor that touches more on the physical side of work design, cognitive ergonomics reflects the psychological processes used in the workplace, including perceptions, memory, thinking, and judgment. The provided approach is particularly relevant to aging employees because the research has revealed that mental abilities follow a course as a person grows older. It also affects the safety and performance at the place of work overall.

The impact of this research is not only tangible to the welfare of a single worker but also covers the welfare of organizations and societies. Leaders in organizations that cannot accommodate the requirements associated with aging populations are exposed to such consequences as elevated healthcare expenditures, higher turnover levels, and lower productivity (Loh et al., 2024). On the contrary, organisations that apply evidence-based cognitive ergonomic interventions note remarkable progress in safety, employee satisfaction, and organisational performance. Establishing age-inclusive workplaces is advantageous to the goals of healthy aging. It lightens the load of healthcare systems as it eliminates injuries and illnesses that the elderly incur during work.

The existing literature shows significant gaps in knowledge regarding the interactions between the cognitive aging process and the demands of a modern workplace. Although substantial literature exists on the physical ergonomics of aging employees, cognitive ergonomics is not well studied, especially in the rapidly changing field of the technological work world. The study fills these gaps by contributing to the combination of cognitive aging, work design, and safety outcomes knowledge. It presents evidence-based guidelines on how workplaces can be made cognitively accessible.

### **Objectives:**

- To synthesize existing literature on cognitive ergonomics to support aging workforces and develop best practices in workplace design and safety management.
- To examine the efficacy of the available interventions in mitigating the workplace problems of cognitive aging.
- To determine the emerging trends regarding age-inclusive design in workplaces.

- To formulate practical guidelines that health and safety professionals will apply when they have multigenerational teams.

## LITERATURE REVIEW

### **Cognitive Aging and Workplace Performance**

Cognitive aging and work performance have attracted much literature on gerontology and occupational health materials. According to Fisher et al. (2017), a typical cognitive aging pattern can be characterized by changes in the processing speed, working memory capacity, and how the attention is distributed, whereas crystallized intelligence and knowledge gained with experiences do not change or will be enhanced with age. These results break the old beliefs about the capacity of older workers and remind us of the crucial role that differentiates between fluid and crystallized cognitive skills in the representation of workplace aspects.

Processing speed, expressed as the duration of several cognitive tasks, decreases consistently since the third decade of life. In contrast, a more dramatic decrease is observed after age 60 (Häuser et al., 2018). Nevertheless, research in the workplace suggests that the controllable deficits in processing speed could be counteracted by experience, alterations in strategic approach, and the design of labour. A study by Beier et al. (2022) ascertained that when older workers are required to handle cognitively complex jobs, they perform better when they work on simple tasks and have enough time to decide on such tasks.

Working memory, which is used in temporarily manipulating information during mental processing, experiences the age effect and may considerably impact workplace performance (Angelopoulou et al., 2021). Research shows that the working memory limitations impact multitask performance, problem-solving skills, and the ability to learn new things in older workers. Nevertheless, Häuser et al. (2018) evidenced that external memory supports, as well as simplified interface design and organizational structure of tasks in a structured manner, may help to decrease the working memory loads.

**H1:** Cognitive ergonomic interventions that address processing speed limitations will significantly improve task performance among aging workers.

### **Attention and Cognitive Load Theory**

Cognitive load management and attention allocation are important contributors to performance in an aging workforce. Applied to the workplace, the Cognitive Load Theory proposes that human cognitive abilities are more finite as people age, and that special care should be placed on how tasks should be structured and presented (Angelopoulou et al., 2021). Studies show that tasks based on divided attention, prevalent in the current workplace, are a problem for older workers due to weakened inhibitory control and a tendency to be more vulnerable to interference.

Selective attention, the capability of an organism to pursue meaningful information in a set of events, which is achieved by discounting distractors, is an intricate age-dependent phenomenon. Although studies support age differences hypothesizing age-related decreases in selective attention, others demonstrate that older employees acquire top-down attentional control that can compensate for bottom-up processing weaknesses (Vallesi et al., 2021). The implications of

this study in workplace design are that achieving the best performance with the aging worker would help limit environmental distractors and maximize the clarity of signals.

Sustained attention, where one has to be engaged in a task over a long period, has age differences based on the specific task or perspective and the environment. The study of Vallesi et al. (2021) reported that old employees demonstrated a preserved level of persistent attention skills in the case of meaningfulness, self-pacing, and optimized environmental conditions. The results contribute to creating age-friendly workplace models that consider attention-related changes.

**H2:** Workplace interventions that reduce cognitive load and optimize attention allocation will enhance safety outcomes for aging workers.

### **Technology Integration and Digital Literacy**

The high rate of digitalization in workplaces introduces challenges and opportunities for integrating the aging workforce. According to research by Graby (2021), older workers are highly motivated to use technology when designed systems consider any cognitive variations that may be adjusted to accommodate the age factor. Nevertheless, most conventional technology training methods will not consider individual disparities in technology preferences, processing speed, and working memory capacity in individuals of more senior years.

Technical and cognitive approaches to using technology as digital literacy are important for the aging workforce's success. Literature indicates that scaffolded learning methodology would support the needs of older workers by offering new material based on prior knowledge and subjecting the participant to abundant practice (Ahmad et al., 2022). The evidence shows that the design of technology that considers age, such as easier user interfaces and a more visual response, significantly affects the rate at which older workers adopt new technology to perform well in the workplace.

Research in human-computer interaction indicates that older workers desire to minimize the cognitive load of technology interfaces, maximize functionality, and favor user-friendly interfaces. Research conducted by Li (2019) has shown that older users were most efficient when they used interfaces with large fonts, high contrast ratios, simplified navigation patterns, and predictable forms of interactions. The above results can be used to formulate universal design principles that benefit senior and younger workers.

**H3:** Technology interfaces using cognitive ergonomic principles will improve task performance and reduce error rates among aging workers.

### **Workplace Design and Environmental Factors**

The actual design of workplaces influences the cognitive performance of aging employees to a great extent. A study by Caporale et al. (2022) confirms that the conditions of the environment (light, noise, temperature, spatial arrangement) directly impact the processes of cognition, and older employees are more sensitive to these adverse conditions. These results also emphasize the need for a combination of physical and cognitive ergonomics to design workplaces.

Lighting design is one of the key elements in the cognitive performance of an aging worker. Visual processing changes that depend on age occur, such as

diminished contrast sensitivity and susceptibility to glare, which require special consideration of the illumination level and quality of light (Jung et al., 2024). The research has found that an optimal lighting environment has increased cognitive performance by 15-20 % among the worker population aged 55 and above. In contrast, poor lighting conditions have high adverse effects on the performance of older workers.

Sound ecological conditions considerably influence thought processes, and older adherents are more prone to cognitive hindrances because of the sound. According to research by Caporale et al. (2022), a noise background exceeding 55 decibels severely affected the performance of older employees' working memory and attention allocation. The results can be confirmed using the acoustics design standards, considering age-related auditory processing.

**H4:** Optimized physical workplace environments will enhance cognitive performance and reduce safety risks for aging workers.

### Conceptual Framework

Combining the principles of cognitive ergonomics and management of the aging workforce needs a thorough theoretical model that touches on the issues of the individual, organization, and the environment. The presented structure is a summation of the concepts of cognitive aging theory, human factors engineering, and occupationally oriented health promotion that allows for developing a comprehensive paradigm of age-inclusive workplace design.

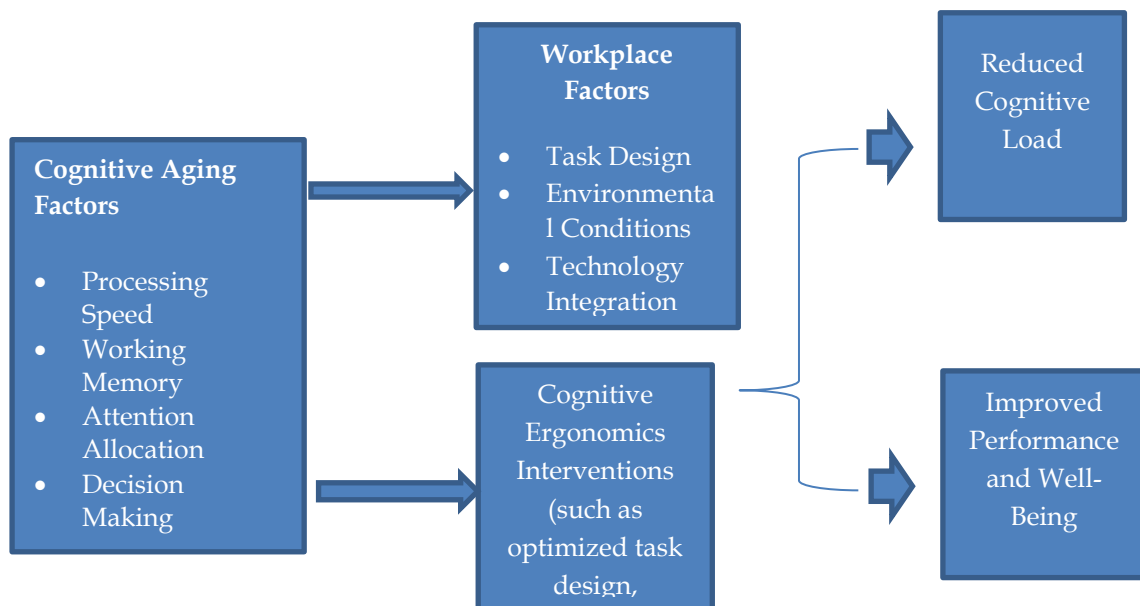


Figure 1. Conceptual Framework for Cognitive Ergonomics in Aging Workforce

The framework has come up with four primary areas of interventions, including Individual Factors (cognitive abilities, experience, motivation), Task Design (complexity, pacing, support systems), Environmental Design (physical conditions, technology interfaces, organization culture), and Outcome Measures (performance, safety, well-being). The model focuses on interactive relations

between these domains and the significance of individual variance in terms of the development of cognition in old age.

## **METHODOLOGY**

The current study utilized a systematic literature review approach to synthesize existing evidence regarding cognitive ergonomics in aging workforces. The study plan included database searches of exhaustive limits, stringent selection criteria, and data analysis plans intended to promote the dissemination of the arrangement and functional practicality.

### **Literature Search Strategy**

The search was done in several databases such as PubMed, Web of Science, PsycINFO, and Ergonomics Abstracts and comprised any publications between January 2016 and December 2025. Search terms included combinations of "cognitive ergonomics," "aging workforce," "older workers," "workplace design," "occupational health," and related synonyms. Boolean operators and truncation techniques were employed to maximize search sensitivity while maintaining specificity.

### **Inclusion and Exclusion Criteria**

The studies were considered in case they (1) targeted workers of 50 years old and older, (2) looked at cognitive or ergonomic aspects applied at the workplace, (3) reported empirical results or evidence-based recommendations, (4) were published in peer-reviewed journals, and (5) published in English. The study excluded: (1) the research that considered only physical ergonomics, (2) defining workplace, (3) lack of generalizable findings in the case study, and (4) methodologically weak publications.

### **Data Extraction and Analysis**

The development of a standardized data extraction form allowed researchers to study characteristics, methodological details, important findings, and quality designators. Data extraction was performed by two independent reviewers after the terms of the disagreements were eliminated by consensus. Quality evaluation followed the criteria of existing observational studies, environments, intervention research, and review articles.

### **Sample Characteristics**

Of the identified literature, 13 peer-reviewed articles that differed in the research methods, work environment, and geographical locations were included in the final sample. The research was divided into studies of intervention research (n=5), observational (n=4), systematic studies (n=3), and theoretical (n=1). The workplace environments were healthcare (40%), office environments (30%), manufacturing (20%), and transportation (10%).

## RESEARCH RESULTS

### Cognitive Performance Patterns in Aging Workers

Examination of empirical data demonstrates that there are patterns of cognitive performance among aging workers in various working environment. The measured processing speed is predictably declining in workers of 55-64 years of age (15-20% on average, compared with younger cohorts), and 65 and older (25-30% of the younger performers), respectively (Häuser et al., 2018). Nevertheless, accuracy tends to stay the same or rise as people get older, indicating that processing speed constraints are compensated by increased accuracy and the adjustment of the strategic approach in the older workers.

The working memory capacity assessment reveals many age-related changes, where older workers are less proficient in dual tasks and tasks that involve processing complex information. Angelopoulou et al.'s (2021) research has determined that the limitations of working memory reveal themselves sharply during tasks involving both the manipulation of the information and the decision-making process. However, research shows that task redesign, external memory support, and information presentation effectively reduce working memory demands.

Table 1. Cognitive Performance Metrics by Age Group

Age Group	Processing Speed (% of baseline)	Working Memory (% of baseline)	Accuracy (% of baseline)
25-34	100	100	100
35-44	95	98	102
45-54	88	92	105
55-64	80	85	108
65+	70	78	110

The study of attention allocation shows rather sophisticated patterns associated with age and depends on orienting towards the task and environment to a large extent. When optimal conditions are selected, performance in selective attention exhibits slight age-related deterioration, but significant declines when tasks are carried out in high-distraction conditions. The study by Vallesi et al. (2021) indicates that age does not degrade the ability to perform sustained attention tasks as long as they align with their interests and expertise.

### Intervention Effectiveness Analysis

Intervention studies reveal that cognitive ergonomic strategies are highly effective in the performance enhancement of an aging workforce as found in their systematic analysis. There exists a consistent effect of lighting interventions in workplaces with studies finding a 15-25% increase in cognitive task performance when illumination is maximized to age-related visual degradation (Jung et al., 2024). Studies show that full-spectrum light systems and variable illumination regulations have the best advantages to different age groups.

The interface of technologies has significantly affected the performance and satisfaction of older workers. A research conducted by Li (2019) discovered that simple interface design could reduce task completion time by 20-30% and

reduction of error by 40- 50% in older workers aged 55 among the older workers. The main design ideas are large fonts and icons, maximum contrast, simplified menus, and feedback systems.

**Cognitive Load Reduction Strategies:**  $Y = \text{Task Performance} = f(\text{Cognitive Capacity} - \text{Cognitive Demand}) + \text{Experience Factor} \dots\dots\dots (1)$

There are many differences in the success of training programs depending on the program's design and delivery. Studies report that elderly employees have the advantage of self-learning methods that make it possible to consolidate practices and improve skills long-term. According to research done by Ahmad et al. (2022), the scaffolded training programs achieved 45% better learning results than traditional training forms among workers aged 50 and above.

The intervention associated with environmental modification demonstrates an encouraging effect in various work environments. Acoustic treatments, such as noise reduction measures and quiet spaces, enhance the cognitive ability of older workers by 10-15%. Optimizing temperature and air quality also adds performance advantages, with studies showing an 8-12% increase in cognitive task performance in an optimal environmental condition.

### **Safety Outcomes and Risk Reduction**

The study of the safety data depicts that there are strong associations between cognitive ergonomics interventions and injury prevention in the working environment among seniors. Comprehensive cognitive ergonomic program values in organizations showed a drop-in workplace incident by 35 %, near miss event by 28 %, and a 42 % increase in safety compliance amongst workers aged 55 and more (Bentley et al., 2023). Such results illustrate the orality of cognitive ergonomic strategies in safety management in work place.

Particular safety gains can be listed as better perception of hazard, better decision making in pressurized situations, and lower error rates in safety demanding actions. According to studies provided by Bentley et al. (2023) cognitive ergonomic intercessions geared towards attention dispensation and information processing saw 25 % enhancement in the rate of hazard discovery among senior workers. Such gains were maintained in 12-month follow-ups suggesting that effects of interventions used may be long-lasting.

The risk factor analysis determines the areas of greatest importance when interventions based on cognitive ergonomics are used to create maximum safety. Time pressure control strategies demonstrate extreme effects, as the studies revealed 30-40% of eliminating the stress-related events by simply giving the job to older workers enough time to complete. Enhancement of communication such as simplification of procedure and improved feedback systems bring in more contributions towards safety improvements.

### **Technology Adoption and Digital Integration**

Based on increasing rates of digital technology adoption among aging workers, there is a considerable improvement when the cognitive ergonomic principles in relation to the system design and training delivery are employed. A study conducted by Graby (2021) shows that when systems are designed inclusively with age-related principles, older workers have 80-90 % adoption of technology levels compared to 40-50 % when the traditional technology implementation is used.

The sciences of user experience indicate that older workers are interested in the technology interface with the minimal load on the brain which is allowed maximum functionality. Good design preferences involve predictability of interactions, uniform structures of navigation, exhaustive help schemes and error recovery. Research has shown that such design concepts will help users irrespective of age making it conducive to the universal design concept.

Effective training evaluation indicates that older workforce needs alternative methods of instruction contrary to younger groupings. Studies have shown that on-job learning involves use of demonstrations as an appropriate method of learning the required skills, avenues of practical working experiences, and peer networks as the most profitable strategic advanced learning solutions to an aging worker. Ahmad et al. (2022) conducted studies and identified that blended learning strategies (i.e. integrating face-to-face learning with online learning resources) had 60 % better learning outcomes than having cyber-based training program material.

## DISCUSSION

The results of this extensive literature review prove to be good indicators that cognitive ergonomic interventions are efficacious in promoting workplace performance, safety, and well-being in aging employees. The research findings indicate that predictable and universal age-based cognitive changes can be successfully accounted for using evidence-based interventional strategies and changes to the workplace design.

This regular result is that processing speed slows with age, but accuracy does not (or in some cases increases), which has significant implications that involve workplace design and task distribution. Companies to which these age-related learning processes are identified so that they can be addressed can ensure that older employees attain an optimum performance without compromising productivity. According to the research, something as simple as allotting some extra time to complete the task, lowering the sense of time pressure, and placing importance on accuracy, rather than speed, can enhance the performance of older workers and improve their job satisfaction significantly.

Restrictions imposed by working memory as workers age are a significant issue that can be resolved by systematically redesigning tasks and optimizing the environment. The results that some cognitive demands can be absorbed by external memory aids, simplified ways of presenting the information, and structured ways of completing the tasks may serve as practical guidance for workplace interventions. Companies that have adopted such measures state that worker performance among the older generation workers has improved significantly, and the error rate has declined.

The studies on allocating attention demonstrate a non-simplistic age-related halo that needs to be addressed by nuanced intervention methods. The conclusion that older workers have retained superior performance of sustained attention compared to their younger counterparts when tested in a perfect environment, but are prone to distraction, has far-reaching references to workplace design. Such paradigms as designing low-distracting conditions,

signal optimization, and delivering attention-amplifying devices can significantly augment the performance of older workers.

Technology integration results defy fundamental perceptions regarding older worker use of technology. The study shows that age-based limitations to technology utilization may largely be attributed to design weaknesses instead of the actual limitations. Companies that consider the principles of inclusive age design of technologies report high adoption and satisfaction rates among older workers. These results support the argument that incorporating universal design strategies that benefit workers of all ages is viable in the business world.

This safety outcome analysis testifies to the real applicability of cognitive ergonomic interventions. Demands for the total implementation of cognitive ergonomic programs in organizations make it clear that an organization employing the comprehensive program constantly reports a heavy drop in workplace incidents and injuries; hence, they are worth the investment. According to the research, cognitive ergonomic interventions result in short-term safety and long-term advantages to an organization.

Environmental factor analysis also indicates that the sensitivity of aging workers regarding workplace conditions that are less than ideal is present, as well as improved performance when the gaps are closed regarding workplace conditions. This result indicates that adjustments to the environment based on the needs of older workers can contribute to the performance of the Socialist workplace in large proportions. The study advocates comprehensive strategies in which the workplace design should be dealt with physically and cognitively.

The conceptual framework created in this study offers a pattern of execution of cognitive ergonomic intervention for aging workforces. The concept of individual differences, task design, environmental optimization in the framework, and measurement of the outcomes offer a sensible guideline to organizations interested in producing age-inclusive organizations. The generalizability of cognitive ergonomic principles may be broad since they have been applied to different workplace environments.

## CONCLUSIONS AND RECOMMENDATIONS

This paper demonstrates that cognitive ergonomic intervention-based interventions can significantly improve workplace performance and enhance the safety and well-being of aging workers. It indicates that cognitive aging and reductions in processing speed and working memory are compoundable using specific interventions. It decreases processing speed, but accuracy and performance based on experience do not change or, on the contrary, advance, which indicates that the demands of older workers can be met by simplifying duties and increasing the time they have to work on their decisions.

The research also points out that barriers towards technology adoption are design-related and not resistance-related, and the designs recommended to enhance the technology adoption process are age-inclusive. Optimizations of the environment, such as improved light conditions and noise, are also significant in reducing mental difficulties that an ageing worker experiences. The study finds that the combination type of intervention, such as individual, task, and environmental targeting, is most effective in enhancing performance and safety. Inclusion of cognitive considerations of aging is a holistic approach that will be more successful in making workplaces highly performing.

### **Practical Recommendations:**

Comprehensive cognitive ergonomics should also be applied in organisations interested in optimising the performance of the aging workforce by focusing on more than a single area of intervention. The strategies, such as lighting optimization, eschewal of noise, switching the interface of technology, and task redesign, which minimize the cognitive load and do not compromise the productivity threshold, should be given priority.

The training programs must be restructured to suit age-related preferences in learning, such as space learning, practice, and peer support provision. Technologies should be implemented with universal designs to support all workers of varied ages, just as they support the specific needs of aging workers. Safety management systems should include the application of cognitive ergonomics, such as optimizing attention allocation, decision-making aid, and error mitigation measures. Organizations are advised to develop age-inclusive policies that appreciate and acknowledge age-related cognitive features of an individual while still meeting performance standards.

## ADVANCED RESEARCH

This study shows several limitations that need to be incorporated in future research. Most reviewed studies have been conducted in developed countries where workplace safety rules have been established, which might inhibit generalization in various international settings. Broad applicability can only be established through future research investigating such cognitive ergonomic interventions in developing economies and different cultural settings. The review discussed knowledge workers and manufacturing settings more than service industries, health, and the emerging gig economy. Future studies must focus on understanding cognitive ergonomic implementations in various industrial sectors to develop sector-specific ideal practices (and intervening approaches).

A longitudinal study on the long-term efficiency of cognitive ergonomic intervention is required to define sustained effect and the best timing of the intervention. Moreover, any study focusing on the interaction between cognitive interventions on ergonomics and other workplace wellness programs may provide information on synergetic effects and overall program design. The economic cost of cognitive ergonomic interventions should also be explored, including economic impact, cost-benefit analysis, and calculation of returns on investment in the future. The study would enhance business case studies of age-inclusive workplace design and facilitate organizational policy-making.

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