Aging Workforce Dilemma: Cognitive-Strained Working Conditions in an Office Setting

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Abstract

Aging is a significant demographic shift with implications for society and the workforce. As people age, cognitive abilities experience degenerative events, leading to functional decline. The objective of this study is to identify cognitively straining working conditions among the aging workforce based on work system-related factors. This study utilized validated questionnaire surveys, such as Carmen-Q and COPSOQ-II, as well as interviews and observations utilizing cognitive work and task analysis. The sample sizes for the survey were 111 aging office workers and 20 aging workforces for the interview and observation sessions. The participants were selected among administration and managerial workers with at least 5 years of working experience in their fields. The results from the survey revealed that packed schedule (82%) was the most cognitively straining working condition among aging workforces. For the interview and observation phase, quantitative tasks were identified as the most cognitively straining working condition (82%). The correlation between work system-related factors and cognitively straining working conditions factors mean score in both phases revealed significant results on workplace and space, participants, and information and task. The results support the influence of work system-related factors on the cognitive strain experienced by aging workforces in an office setting. Identifying these variables is crucial for monitoring the well-being of aging workers. Considering their cognitive decline, tailored interventions are essential. This study provides insights to help design better work systems for aging employees, assisting organizations in identifying risks and improving overall performance.

1. Introduction

The demographic transition is now occurring worldwide. The United Nations reported in 2015 that the global population grows at an average rate of 1.2% per year. In 15 years, the world population is projected to increase by more than one billion people. More than 15% of the global population consists of elderly individuals, who were previously baby boomers that have reached or will reach 65 years of age. This indicates a clear shift toward an aging population (Stedmon et al. 2012; Harasty & Ostermeier 2020).L As this trend continues, aging will have a significant impact on the world population structure from 2015 to 2060 (The Economist Intelligence Unit, 2015). Consequently, the aging workforce is becoming more dominant in numbers, leading to changes in retirement legislation (Stedmon et al. 2012; White, Burns, and Conlon 2018).

In Malaysia, the elderly population has doubled from 7% to 15% within the past 28 years and is projected to reach 15% of the total population by 2030 (Jacob 2016). According to the Ministry of Human Resources in 2016, statistics for employment and labor in 2015 indicated that 26.1% of the total workforce in Malaysia was in the age of 45 years and above, with 2.8% constituting the aging workforce (60 years and above). Although the current Malaysian population is relatively young, changes in the age structure are emerging. In response to this phenomenon, Malaysia extended the retirement period by increasing the retirement age from 58 to 60 years in 2012 (Abas et al. 2018).

This shift presents both challenges and opportunities for nations. The concept of dynamic national capabilities, which encompasses a country's ability to adapt, innovate, and thrive amidst global changes, is significantly influenced by the characteristics and performance of its workforce (Amaral et al. 2023; Elizabeth et al. 2024). An aging workforce, with its wealth of experience and knowledge, represents a valuable asset. However, cognitive strain and work-related stress can hinder the productivity and engagement of older employees, posing a risk to these national goals.

Malaysia Productivity Corporation (MPC) highlighted in its "Productivity Report 2016/2017" that local labor productivity increased by 3.5% in 2016 to Ringgit Malaysia (RM) 78,218 from RM75,548 in 2015. The service sectors showed the second-highest figure at RM68,166 with a growth of 2.8% (Dahalan

et al. 2022; Stedmon et al. 2012). The positive trends reported by MPC are undoubtedly contributed by the presence of an aging workforce in each sector, as aging workforces are known to possess more experience and knowledge compared to younger workers in problem-solving and decision-making (Jenkins 2019; Gonzalez and Morer 2016) and capable of preparing graduates who usually require on-site training and better equip them to become respected and useful contributors in their industry (Afshin et al. 2024).

However, the positive trends were made possible at a great cost. Over time, the human body experiences degenerative changes at the molecular and cellular levels, known as the aging process (van der Cammen at al. 2019; Merkel at al. 2019). During these events, there is a deterioration in physical and mental functions, an increased risk of sickness, and eventually, death (Rudnicka et al. 2020; Husic et al. 2020; Sewdas et al. 2017; Hassim 2018). Nowadays, it is a common practice among institutions and organizations to assign high-value aging workers to roles involving office work. Work in an office setting is commonly known as knowledge work, which deals with complex interactions involving more ambiguity, analyzing, learning, and acting on information (Haghighat et al. 2023a; Avinante et al. n.d.; Haghighat et al. 2023b). For aging workers, knowledge work might be challenging as they experience decreases in reaction time of up to 50% due to aging. In information processing involving short-term and long-term memory, aging workforces might be less efficient compared to younger individuals. Despite the issues with reaction time and efficiency, some studies suggest that older people are almost up to 50% faster in catching up when it comes to work-related knowledge. However, in learning new skills, aging workers require up to 50% more training time (Fox et al. 2015). These findings are significant for work-related task issues in highlighting the cognitively straining working conditions in an office setting among aging workforces.

The Fourth Industrial Revolution has been the result of modern digitalized work environments. The performance of work tasks in these environments relies heavily on cognitive functioning, which encompasses mental processes governing information processing, such as attention, working memory, decision-making, and learning (Michel et al. 2014; Indeed Editorial Team 2023; Barrett 2023). These demanding requirements are particularly crucial in knowledge work jobs involving aging workforces as they are required to work with abstract knowledge; acquire, create, and apply knowledge; and engage in continuous on-the-job learning (Pyöriä 2005; Sørensen and Holman 2014; Strasser 2018). The cognitive capacities of aging workforces reach their natural limitations during the aging process and may respond differently to conditions (Fox et al. 2015). For instance, in office work tasks, the cognitive demands of work tasks are translated into cognitive load. This cognitive load has a certain threshold limit, and when exceeded, it leads to cognitive strain, often originating from working conditions (Kalakoski et al. 2020). Several studies focusing on disruptions and interruptions in working conditions have shown that many working conditions impair cognitive performance (Jahncke et al. 2011; Couffe & Michael 2017). Moreover, aging workforces are also exposed to requirements related to fragmentation of work, multitasking, and information overload. These events have been proven to be predictable straining features in numerous fields, including knowledge work tasks (Woods and Dekker 2000; Douglas et al. 2017) .

In an office setting, aging workers' work performance is at risk when exposed to cognitively straining working conditions, which disrupt the human ability to master cognitively demanding work tasks. The work environments, including humidity, acoustics, lighting, working shifts, and working hours (Dahalan et al. 2022) in office settings are constantly exposed to disruptions and interruptions. Office-related tasks are often disrupted by speech and office noise (Jahncke et al. 2011; Venetjoki et al. 2006; Röer, Bell, and Buchner 2014), while workers' task performance is at risk of harmful consequences due to interruptions (Couffe and Michael 2017; Foroughi et al. 2014; Monk et al. 2008). Furthermore, another critical hindrance to task performance is information overload due to multitasking or new interaction technologies (Duggan et al.2013; Gupta et al.2011; Mansi & Levy 2013; Rennecker & Godwin 2005). Cognitively straining working conditions affect both younger and aging workers by impairing cognitive functioning and task performance. However, due to the aging phenomenon, aging workforces are more susceptible to cognitive failures, which compromise overall performance. This situation creates a dilemma among aging workforces as different companies and organizations adopt a wide range of ages in defining an "older worker," from 40 to 65 or more (Juhn et al. 2012; Kollmann et al. 2020).

In this study, work system-related factors are crucial to be examined due to their roles in the occurrence of cognitively straining working conditions. Work system-related factors comprise participants, workplace and space, information and task, technology and tools, and organization. Previous researchers proposed that these factors significantly contribute to the overall work system. In the office setting, aging workforces are considered to be the work system

participants who hold psychosocial, cognitive, and physical characteristics. The workplace and space factor defines the suitability of the workstation and the surrounding area for aging workers. Some workplaces may have challenging features, such as numerous stairs or distant rest areas, which can negatively impact aging workers' well-being and productivity. Office settings nowadays utilize modern technology and tools in task execution, which can be challenging for aging workers. They might find difficulty concerning current technological advancements, particularly in ergonomic-driven technologies. These include their familiarity with online storage systems, virtual meetings, research assistants, data handling tools, virtual brainstorming platforms, natural language processing software, optical character recognition devices, programming software, and virtual collaboration platforms. The fifth factor, the organization, reflects the level of support for aging workforces. This factor consists of policies, practices, and resources available to assist them in engaging in their roles in an office setting. By evaluating this factor, researchers can determine the extent to which the organization values and prioritizes the well-being and productivity of their aging workforce.

The objective of this study is to identify cognitively straining working conditions among aging workforces in an office setting based on work system-related factors. Two hypotheses were analyzed: H1: The current office work system is the source of cognitively straining conditions for aging workers, and H2: The current office work system is not the source of cognitively straining conditions for aging workers. The results from this study will assist researchers in expanding future research and the scope of findings and also guide organizations and authorities in developing an appropriate work system for aging workforces, thereby improving their performance as professional workers. By recognizing and addressing cognitive strain, professionals can improve outcomes, enhance well-being, and optimize performance in various contexts.

2. Methods

2.1 Sample

A cross-sectional study was conducted and divided into two phases: Phase 1 survey, was carried out by online survey, and Phase 2 interview and observations was conducted through a series of structured interviews and direct observations at the participants workplaces. Participants were selected among aging office workers with inclusion criteria of 1) with computer literacy, 2) minimum of 5 years working experience and 3) age above 50 years. The survey was discreet, voluntary, and could be terminated at any moment without penalty. A pilot study was carried put for each phase to ensure the compatibility of the study design for the participants. This research was approved by Ethics Committee for Research Involving Human Subjects (JKEUPM), Ref. no: UPM/TNCPI/RMC/JKEUPM/1.4.18.2 (JKEUPM).

The survey sample size was set based on sample size calculation by previous researchers, resulting in 111 aging workers (mean age M= 52.75; 67 men and 44 women) recruited from random locations in Malaysia. Most participants' age is within the range of 49 - 67 years old.

Interviews and observations involved participants from different sectors comprising of education, manufacturing, and public administration, compulsory social activities, resulting in 20 aging workers (mean age M= 54.50; 8 men and 12 women) recruited from random premises in Malaysia. Range of age among participants is between 50 to 67 years old. The total number of participants recruited are sufficient and diverse in representing an aging workforce in an office setting in Malaysia.

2.2 Tools for Data Collection

The CarMen-Q Questionnaire and the Copenhagen Psychological Questionnaire were two primary tools utilized in this research (COPSOQ-II). Results on quantitative demands, cognitive demands, general health perception, burnout, and cognitive stress were analysed from COPSOQ-II while findings for mental workload comprised of cognitive demands, temporal demands, and performance demands were analysed from CarMen-Q (Berthelsen et al. 2018; Rubio-Valdehita et al. 2017; Moncada et al. 2014). These factors were deemed the most appropriate and relevant within the scope of this study. The survey's questions were revised to better suit the age range based on results from the pilot study. The analysed results and finding were then utilized to construct the interview and observation phases. The phase's outcome is then compared to produce a better result.

The survey questionnaire was structured into four sections. The first section, labelled Section A, consists of demographic questions aimed at gathering participant details. Section B is composed of objective questions in the form of a scale-based questionnaire, focusing on variables that potentially be the source of cognitive-strained conditions among aging workers. Section C involved subjective questions that explore participants' awareness of current technology, particularly in the context of ergonomic-driven advancements. Finally, Section D addressed personal consent, allowing participants to indicate whether they agreed to be contacted for potential involvement in future

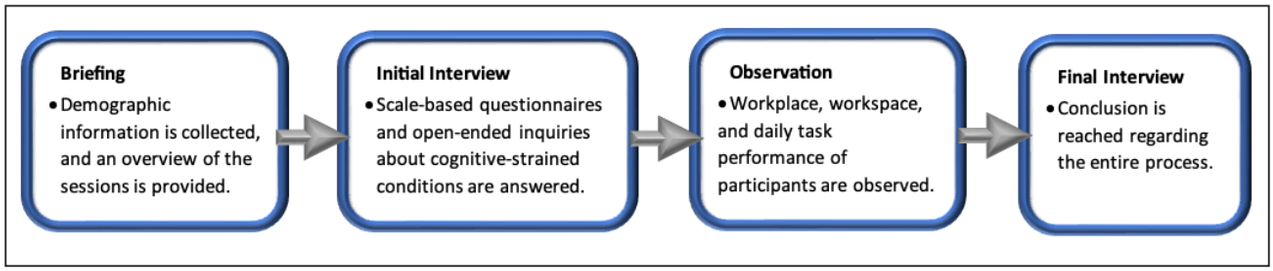

Figure 1. The organization of four distinct sessions during interviews and observations method.

stages of the research. The questionnaire has been tailored according to the needs of the study objectives and the compatibility with the target participants, by referring to the pilot study result. The tailored questionnaire can be referred to Appendix A.

The interviews and observations were organized into four distinct sessions (Figure 1). The first session, named the Briefing, entailed providing participants with an overview of the sessions ahead, as well as collecting their demographic information. The second session, the Initial Interview, comprises a combination of scale-based questionnaires and open-ended inquiries, aimed at exploring the variables that may result in cognitive-strained conditions among aging workers. The questionnaire has been tailored according to the needs of the study objectives and the compatibility with the target participants, by referring to the pilot study result. The tailored questionnaire can be referred to Appendix B. Moving on to the Observation session, the focus was on observing the participants' workplace and workspace, as well as their performance in their daily tasks. Lastly, the Final Interview served as a conclusion to the entire process and delved deeper into the outcomes and findings derived from the sessions.

2.3 Cognitive-strained Working Conditions

Analysis of the questionnaire results was conducted to identify cognitive-strained working conditions among the aging workforces. The outcomes provided valuable insights into the current working conditions experienced by aging workers in office setting, which demonstrate whether they faced cognitive-strained conditions or not. Several variables were used to gauge the prevailing working conditions, encompassing cognitive demands, temporal demands, performance demands, quantitative demands, and cognitive stress. These variables were presented in the form of questions such as "Does your job require memorizing a high amount of data?" (cognitive demand), "Is your job expected to be error-free?" (performance demand), and "Is the pace of your work excessively fast and challenging for even experienced workers to meet?" (temporal demand). A total of 12 variables were tested to assess cognitive-strained conditions (cognitive, temporal and quantitative demands, possibilities for development, quality of leadership, social support, quantitative demands, safety of workplace, cognitive demands, physical and mental health, facilities at workplace, and overall workplace).

Results of the analysis presented the factors that contributed to cognitive-strained working conditions among aging workers in their respective workplaces. These findings shed light on specific aspects of aging worker jobs that posed challenges, offering valuable information for addressing and improving the working conditions of aging workforces.

2.4 Work System related Factor

In this research, work system-related factors were considered, encompassing participants, workplace and space, information and task, technology and tools, and organization. Previous researchers (Drabe et al. 2015; Raab 2020) have suggested that these factors significantly contribute to the overall work system. These mentioned factors are quantified based on selected questionnaires from CarMen-Q and COPSOQ II assessments; the questionnaire is then categorized based on these two tools. The participants factor relates to the individuals performing the work, considering their psychosocial, cognitive, and physical characteristics. The results concerning this factor shed light on the satisfaction levels of the aging workers within these dimensions.

The workplace and space factor explore the suitability of the workstation and the surrounding area for aging workers. Some workplaces may have challenging features such as numerous stairs or distant rest areas, which can negatively impact aging workers' well-being and productivity. This aspect is crucial in determining whether the work environment adequately supports the needs of an aging workforce.

Additionally, the technology and tools factor will gauge the awareness level of aging workers concerning current technological advancements, particularly in ergonomic-driven technology. This includes assessing

their familiarity with online storage systems, virtual meetings, research assistants, data handling tools, virtual brainstorming platforms, Natural language processing (NLP) software, optical character recognition (OCR) devices, programming software, and virtual collaboration platforms. Understanding their level of awareness in these areas will provide valuable insights into how well-equipped aging workers are with modern technological tools.

Lastly, the organization factor will examine whether the current work system is supportive of aging workforces or not. It will enlighten the organization's policies, practices, and resources available to assist aging workforce in their roles. By evaluating this factor, researchers can determine the extent to which the organization values and prioritizes the well-being and productivity of their aging workforce.

Each of these factors will undergo rigorous analysis to identify the critical elements that significantly impact aging workers within the current office work system. This comprehensive approach will offer valuable findings to enhance the overall work environment and support the needs of aging workers effectively.

2.5 Statistical Analysis

Analysis of the study will be carried out according to the objectives by using the IBM Statistical Package for Social Science (SPSS) for Windows version 27.0. H1 and H2 were tested using Spearman's Correlation with two-tailed test which capable of handling any values. The sign of the correlation coefficient indicates the direction of the relationship, while the magnitude of the correlation (how close it is to -1 or +1) indicates the strength of the relationship.

3. Results

This study demonstrates that aging individuals in the current workforce are distributed in professional area involving scientific and technical fields, public administration, defence, social activities, and manufacturing. Further distribution on participants-work industries category is presented in Table 1.

3.1 Cognitive-Strained Working Condition Factors

Questionnaire analyses on the current work system involving aging workforce enable researchers to determine the presence of cognitive-strained working conditions. Among the factors considered, namely performance, cognitive, and temporal demands, this study found that these demands had a significant negative impact on aging workforce.

Overall mental workload is 68% (Figure 2), which suggests that the mean of combination of these three types of demands can create a high level of overall mental workload for aging workers in office settings, which is a critical finding indicating the magnitude of the challenges faced by aging workers.

Moreover, the current office work system assigned to aging workers reveals several factors that adversely

Table 1. Student Ratings of Learning on Relevant Objectives.

Phase	Category	%
Survey	Professional, Scientific and Technical Activities	25
	Public Administration and Defence	22
	Manufacturing	11
	Information and Communication	9
	Others	33
Interview and Observation	Public Administration and Defence	75
	Financial Activities	15
	Others	10

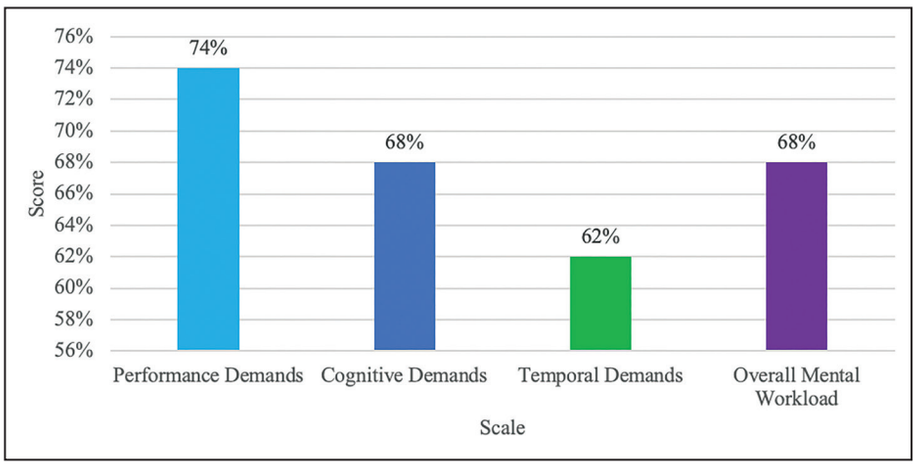

Figure 2. CarMen-Q scores.

Table 2. Comparison on Analysis on Survey Phase and Interview and Observation Phase.

Phase	Survey	%	Interview and Observation	%
Cognitive-strained Working Condition Factors	Pack Schedule	82	Quantitative Tasks	82
	Information Processing	65	Burnout	65
	Safety	61	Cognitive Tasks	64
	Handling Clients Online	60	Temporal Workload	62
	Handling Data	59	Safety of Workplace	56
	Time pressure	55	Somatic Stress Condition	56
	Health Condition	53	Facilities of Workplace	46
	Facilities of Workplace	48	Health Condition	45
	Comfortness of Workplace	41	Comfortness of Workplace	44

affect them. These negative factors include challenges related to a packed schedule (82%), information processing (65%), workplace safety (61%), handling online clients (60%), handling data (59%) and time pressure (55%), resulted into a means score of 64%.

The participants also acknowledged that their declining cognitive function makes the current job structure time-intensive for them. Additionally, workplace safety has a negative impact on aging workers, especially concerning the presence of stairs and the design of furniture, particularly chairs and tables. Dealing with online clients also poses a challenge for aging workers, as they prefer face-to-face meetings than handling online clients.

In the interview and observation phase, the cognitive-strained working conditions were re-evaluated to validate the findings from focus group of target participants. From this phase, six conditions were revealed to be particularly cognitive strains for the participants: quantitative tasks (82%), burnout (65%), cognitive tasks (64%), temporal workload (62%), workplace safety (56%), and somatic stress (56%), resulted into a means score of 64%. The results are listed in Table 2.

3.2 Work System Related Factor

The researchers evaluated five aspects of the work system: organization, information and task, workplace and space, participants, and technology and tools. These aspects were evaluated using five rating namely very satisfied (1), satisfied (2), neutral (3), unsatisfied (4), and very unsatisfied (5), the results are then converted into percentage for easier understanding.

Findings regarding the dissatisfaction level of aging workers revealed that the organization component received a favourable rating of 29%. This indicates that the current organization policies are effectively assisting aging workers in adapting to the challenges posed by the new technological system. On the other hand, the results for the information and task (67%), workplace and space (54%), and participants (46%) aspects were unsatisfactory and deemed inappropriate for aging workers. These three variables are crucial areas that require improvement to better suit the needs and preferences of aging workforce. Enhancing these aspects may contribute to a more positive and supportive work environment for an aging workforce.

Table 3. Comparison on Analysis on Survey Phase and Interview and Observation Phase.

Phase	Survey	%	Interview and Observation	%
Work System Related Factor Negatively Effect	Information and Task	67	Information and Task	63
	Participant	54	Participant	63
	Workplace and Space	46	Workplace and Space	49
	Organization	29	Organization	36

Findings obtained from the interview and observation phase align with those from the survey phase. The dissatisfaction levels of participants were 63%, while both information and task aspects, as well as workplace and space, scored 63% and 49%, respectively. However, the organization aspect received the lowest rating at 36%, indicating that it remains favourable to aging workers. For a detailed analysis, comparison of the survey phase and interview and observation phase are presented in Table 4.

Table 4. Awareness of Cognitive Ergonomic -Driven Technology.

Phase	Category	%
Survey	Aware	48
	Not aware	52
Interview and Observation	Natural Language Processing (NLP)	77
	Optical Character Recognition (OCR)	64

In the survey phase, it was found that only 48% of the participants were aware of the technology and tools being used in their work environment. During the interview and observation sessions, significant improvement in awareness was observed. In this phase, 77% of the participants demonstrated awareness of NLP technology, while 64% were aware of OCR devices. These results were then tested again by focusing on NLP and OCR devices since findings from previous research stated that these device and software are more friendly to aging workers as they able to assist them in cognitive-strained work task (Chumwatana and Rattana-Umnuaychai 2021; Gorai and Nene 2020). However, this study only measures the awareness of aging workers to the technology, and not testing the effect of the technology to the workers.

3.3 Correlation between Aging Workers Cognitive-Strained Condition and Work Ssystem Related Factors in an Office Setting

In this study, a Pearson correlation with a two-tailed test at a 95% confidence level was employed to examine the relationship between the mean value of cognitive-strained working conditions and each work system-related factors, which include participants, workplace and space, information and task, and organization. The factor of tools and technology has been discarded in this phase as that factor only measure the awareness of the aging workers to the current technology and do not have any relationship to the straining working conditions. The results were organized into two phases and are presented in Table 5: Phase 1, the survey, and Phase 2, the interview and observation.

Phase 1 results revealed significant correlations between cognitive-strained working conditions mean score and three work system-related factors. The correlation coefficients for information and task ($r=0.670$, $p<0.001$), participants ($r= 0.788$, $p<0.001$), and workplace and space ($r=0.824$, $p<0.001$) indicated a statistically significant and positive linear relationship with cognitive-strained conditions in the workplace. This supports the hypothesis (H1) that the current office work system is the source of cognitive-

Table 5. Correlation between Mean Value of Cognitive-Strained Working Conditions and Each Work System-Related Factor.

Phase	Survey	*R-value*	*p-value*	Interview and Observation	*R-value*	*p-value*
Correlation between	Workplace and Space	0.824**	< 0.001	Participant	0.796**	<0.001
Work system Related factor and Cognitively Straining Work Condition	Participant	0.788**	< 0.001	Workplace and Space	0.669**	0.010
	Information and Task	0.670**	< 0.001	Information and Task	0.459*	0.042
	Organization	0.016	0.871	Organization	0.265	0.042

**. Correlation is significant at the 0.01 level (2- tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

strained conditions for aging workers. The strength of these associations was considered relatively strong (r >0.50), indicating that these variables tend to increase together throughout the research.

However, the correlation result for the organization factor showed a different outcome (r= 0.016, p=0.871). This indicated that the organization factor had no significant relationship with cognitive-strained conditions for aging workers at their workplace, thus supporting the hypothesis (H2) that the current office work system is not the source of cognitive-strained conditions for aging workers. The strength of this association was relatively weak (r < 0.30).

In Phase 2 of the study, the correlation analysis indicated significant relationships between cognitive-strained working conditions mean score and three work system-related factors. The correlation coefficients for participants (r= 0.796, p<0.001), workplace and space (r=0.669, p=0.01), and information and task (r=0.459, p=0.042) demonstrated a statistically significant and positive linear relationship with cognitive-strained conditions in the workplace. These findings further support the hypothesis (H1) that the current office work system is the source of cognitive-strained conditions for aging workers. The strength of these associations was relatively strong (r >0.50), indicating that these variables tend to increase together throughout the research.

Conversely, the correlation result for the organization factor showed a different outcome (r= -0.265, p=0.258). This indicated that the organization factor had no significant relationship with cognitive-strained conditions for aging workers at their workplace, reinforcing the hypothesis (H2) that the current office work system is not the source of cognitive-strained conditions for aging workers. The strength of this association was relatively weak (r <0.30).

Based on the result, it can be concluded that these three factors, workplace and space, participants, and information and task, were cognitively straining to aging workers. The workplace and space factor result from conditions such as working for a long period of time without a proper rest, which led to backache and eyestrain; a resting area far from aging workers' workplace and lastly, working with outdated facilities and equipment (Becker and Fiske 2022).

The participants factor involved conditions where participants are subjected to packed schedules throughout the day or week. This condition forces aging workers to work beyond their limits, resulting in physical and mental exhaustion and eventually affecting their overall health conditions (Malik et al. 2022).

The information and task in work system-related factors explained conditions where aging workers need to handle complex and large amounts of data. Aging workers also experiencing cognitively straining conditions when required to think and choose different types of alternatives in problem-solving situations. Lastly, uneven distribution of work tasks also resulted in cognitively straining condition (Malik et al. 2022).

4. Discussion

4.1 Survey

The overall mental workload is 68%, which suggests that the combination of these three types of demands (performance, cognitive, and temporal) can create a high level of overall mental workload for aging workers in office settings. This indicates that the cognitive and mental demands placed on aging workers are significant and may lead to work-related stress and burnout (Crawford et al. 2010). In the context of this study, mental workload refers to the amount of cognitive effort required to perform office tasks by aging workers. The score indicates that the participants perceived their workload as relatively high. This finding is consistent with the previous research on aging workers, which suggests that they may experience increased mental fatigue and cognitive decline as they age. Similarly, López-Núñez et al. (2020) stated that burnout is related to work-related demands, such as workload, as well as temporal and emotional demands. Thus, workers who perceive a high degree of workload will be more likely to experience job burnout and exhaustion at work. Additional findings by Rozman et al. (2019) indicate that there is a strong and adverse relationship between workers' occupational stress and their level of work satisfaction (the higher the perceived stress, the lower the workers' work satisfaction on average). Prolonged exposure to cognitive strained working conditions may lead to burnout.

Among the identified factors, a packed schedule emerged as a significant source of cognitive strain for the aging workers and this include the time management skills and affecting the productivity of the workers (Bjärntoft et al. 2020; Gamboa et al. 2021) . The high dissatisfaction rate of performance demands (74%) indicates that managing multiple tasks and meeting deadlines can impose a considerable cognitive load on individuals. This finding underscores the importance of effective time management strategies and workload distribution to mitigate cognitive strain and enhance task performance among aging workforces. A similar study revealed a significant positive correlation between a packed schedule and stress levels. Participants who reported having a

high workload and experiencing time pressure were more likely to experience higher levels of stress. The study also found that individuals who had difficulty managing their time and prioritizing tasks were more susceptible to stress (Amanya et al. 2018).

From the survey, out of all the work system-related factors, the percentage of dissatisfaction with information and tasks is the highest. This suggests that aging workers may find difficulties in meeting requirements of the job or feel overloaded with information. Organizations can solve this issue by using ergonomic design to optimise complex tasks and lessen the cognitive burden on aging workers. This may involve redesigning work processes or providing appropriate training to ensure that aging workers can effectively manage the information and task demands.

To determine the significant levels of each work system related factor with cognitive-strained working condition factors, a Pearson's correlation with two-tailed test was performed to understand the relationship between each factor. The aim of this analysis was to test the two hypotheses related to the cognitive strain experienced by aging workers in the current work system. Hypotheses H1 and H2 were tested using Pearson's correlation with a two-tailed test. Pearson's correlation is a measure that assesses the strength and direction of the relationship between two variables; H1: The current office work system is the source of cognitive-strained conditions for aging workers and H2: The current office work system is not the source of cognitive-strained conditions for aging workers.

The study revealed a correlation between cognitive strain in the work environment and various work system-related factors. The factors related to participants, workplace and space, information and task were found to support the H1 hypothesis, while the organization factor supported the H2 hypothesis. The observed results can be attributed to the unique circumstances of aging workers. As stated in the introduction, aging individuals tend to experience a decline in cognitive and physical functions, including issues like poor memory, a weaker immune system, and reduced physical and mental (Varianou-Mikellidou et al. 2020; Schmillen 2020). Overall, these findings emphasize how critical it is to address cognitive-strained working conditions and enhance the working environment that are friendly to aging workforce. This goal can be attained by putting in place strategies like workload management, ergonomic design, training programmes, and technology support. Organizations can effectively utilize the knowledge and experience of aging workers while fostering their productivity and well-being by fostering a supportive and inclusive work environment.

Improving awareness among an aging workforce about current technology is essential to prepare them for the challenges of the modern era. As technology continues to advance rapidly, it is crucial for aging workforce to stay up-to-date with the latest tools and trends to remain competitive in the workforce (Flavián et al. 2022). Aging workforces need to prepare themselves for the next industrial revolution, which depend on artificial intelligent (AI) systems. This can be achieved by training them in use of ergonomic-driven technology and AI systems. Other than that, an age-friendly environment can be implement by using ergonomic-driven technology to boost their productivity (Calzavara et al. 2020).

4.2 Interview and Observation

Interviews and observations were conducted to further investigate the identified factors in the survey. Quantitative tasks received the highest score of 82%, indicating a strong agreement among participants. They recognized that tasks involving numerical analysis, data processing, calculations, or financial complexities impose a substantial cognitive load. The high quantitative tasks place significant strain on their cognitive capabilities. According to (Carolina Paulo et al. 2012), people's cognitive abilities, such as memory, attention, and processing speed, may deteriorate with age. In addition, it may become more challenging to carry out tasks that involve numbers, such as mental arithmetic or remembering phone numbers due to this deterioration. The cognitive task received a score of 64%. Participants agreed that complex tasks, problem-solving, decision-making, and information processing requirements impose significant cognitive challenges and strain. Such demands can tax their cognitive resources and impact their performance. Cognitive tasks can be more challenging for aging workers and make it harder for them to focus on tasks that require sustained attention (Jansen & Keller 1999; Nagarajan and Sixsmith 2023). Tasks with high cognitive demands typically require more mental effort and concentration, as they involve complex information processing, multitasking, or the need to filter out distractions.

Participants reported a higher level of agreement, with a score of 65%, regarding the burnout condition. This highlights their recognition of work-related stress, exhaustion, and reduced motivation as significant contributors to cognitive strain. Prolonged exposure to burnout conditions can have detrimental effects on cognitive functioning and overall well-being. (Kumar et al. 2019) stated that worker "burnout" is a common outcome of the repetitious, demanding, and stressful job that they encounter on a regular basis). Regarding temporal workload, par-

ticipants expressed a score of 62%. This indicates their agreement with the idea that time pressure, deadlines, and multitasking requirements impose a considerable cognitive load, making it challenging to meet work demands effectively. This fact is supported by previous research by Monaco et al. (2010) who stated that cognitive skills including memory, concentration, and processing speed may deteriorate as people become older. They may find it more challenging to keep up with faster-paced activities or duties that call for quick thinking or decision-making.

For the work system related factor, participant individual factor and information and task are crucial factors. The result reported a dissatisfaction level of 63% for the Participant's individual factor. This suggests that there was some level of participant dissatisfaction with aspects of the work system that were specific to them as individuals. This includes things like their health, how they feel physically and mentally, and how satisfied they are with their jobs overall. It's possible that the participants were under emotional distress, which influenced their general wellbeing and added to their dissatisfaction. In terms of the information and task factor, participants expressed a dissatisfaction level of 63%. This shows that the participants' level of dissatisfaction with various aspects of their task and the handling of information was moderate. Participants specifically expressed concerns about the difficulty of the tasks given to them, the handling and processing of complex information, and the availability of the information required for completing their tasks successfully. They might have thought the tasks were difficult and required a lot of cognitive loads, which added to their dissatisfaction. Additionally, participants may have experienced challenges in accessing and retrieving the information they needed to complete their tasks efficiently.

The results demonstrate that a significant portion of the aging workers, approximately 77%, showed awareness of NLP technology. This suggests that a considerable number of participants were familiar with the concept and potential applications of NLP in their work environments. They recognized its ability to process and analyse natural language data, which can contribute to improving various tasks such as document analysis, information retrieval, and automated content generation. Furthermore, the findings revealed that approximately 64% of the participants displayed awareness of OCR technology. OCR enables the recognition and conversion of printed or handwritten text into machine-readable formats, facilitating the digitization and manipulation of documents. The participants who demonstrated knowledge of OCR acknowledged its potential benefits in enhancing productivity, data entry accuracy, and document management processes.

The study utilized Pearson's correlation analysis to explore the connections between work system factors and cognitive-strained working conditions in an aging workforce. The results unveiled significant correlations between various factors and cognitive strain. Specifically, there was a strong positive correlation between participant characteristics related to aging and cognitive strain, suggesting that an increase in aging-related characteristics leads to higher cognitive strain levels. Additionally, a moderate positive correlation was observed between workplace space and cognitive strain, indicating that improved availability and adequacy of workplace space are associated with higher cognitive strain levels in aging workforce. Furthermore, there was a weak positive correlation between information and task complexity and cognitive strain, suggesting that as the demands and complexity of information and tasks increase, there is a slight rise in the likelihood of experiencing cognitive strain. However, no significant correlation was found between organizational factors and cognitive-strained working conditions. While the current study found no significant correlation, it contradicts the findings of (Calvo, Carlos, and García 2018), who argued that organizational factors play a crucial role. According to their research, organization factors can act as protective measures against chronic stressors in the workplace.

4.3 Implications and Particle Recommendations on Mitigating Cognitive Strain among Aging Office Workers.

The results of this study underscore the need to address cognitive strain among aging workers in office environments. The high levels of mental workload reported by participants highlight the significant increase in vulnerability to work-related stress and burnout mental consistent with prior research by (Mendes & Miguel 2024; Lai et al. 2023; Sørensen and Holman 2014). These findings suggest that organizations must implement cognitive ergonomics interventions to reduce these challenges.

One of the primary implications is the necessity for effective workload management strategies. The high dissatisfaction rate with performance demands among aging workers underscores the importance of prioritizing and distributing tasks efficiently. Organizations should consider flexible scheduling options that accommodate the varying energy levels and cognitive capacities of older employees (Lai et al. 2023). This approach can help alleviate the stress associated with packed schedules and multiple task management, thereby reducing overall cognitive load.

Ergonomic design also emerges as a critical factor in reducing cognitive strain. The dissatisfaction with information and task-related factors suggests that aging workers may struggle with complex tasks and information overload. Implementing ergonomic principles to redesign work processes can simplify tasks, making them more manageable for older workers. This may involve automating repetitive tasks, breaking down complex tasks into smaller steps, and ensuring that workstations are ergonomically optimized to reduce both physical and cognitive strain (Castellote-Caballero et al. 2024; Juhn et al. 2012; Tahernejad et al. 2022). The findings from this work can serve as a reference and are beneficial for engineering technology courses and capstone projects focused on designing work systems for an aging workforce.

Training programs are another essential component in addressing cognitive strain. Providing aging workers with training on the latest technologies and tools can help them stay current and reduce the cognitive load associated with learning new systems (Ekinci et al. 2019; Molino et al. 2020; Castellote-Caballero et al. 2024). Additionally, training focused on time management and stress reduction can empower employees to handle their workload more effectively and maintain their well-being. This is particularly relevant as technology continues to advance, necessitating of lifelong learning and adaptability (Alzaydi 2023).

The integration of AI and ergonomic-driven technology offers further potential to support aging workers(Alcover et al. 2021; "Generative AI and the Future of Work in America" 2024). AI can automate routine tasks and provide cognitive assistance, enhancing productivity and reducing the mental effort required for various tasks. Ensuring that software and technological tools are user-friendly and intuitive can also minimize the cognitive burden on older employees, making it easier for them to navigate and utilize these systems effectively (Weibo 2023; Kalakoski et al. 2020; Kang et al. 2021).

Lastly, creating an age-friendly work environment is crucial for leveraging the experience and knowledge of the aging workforce (Price & Lee 2022). A supportive work culture that promotes inclusivity and understanding can help reduce the stigma associated with aging and cognitive decline (Kocsis et al. 2019). Regular assessments of the work environment and cognitive demands can identify areas needing intervention, while health and wellness programs focusing on physical and mental well-being can support aging workers in maintaining their health and productivity.

5. Limitation and Opportunities for Future Rresearch

In addition to discussing the findings, it is crucial to critically reflect on the study and its procedures. One limitation of this study is its relatively small sample size, consisting of only 111 aging office workers for survey and 20 aging workers for interview and observation. To ensure more reliable results, it is recommended to increase the sample size and include a broader range of industries. Another concern is whether all participants fully understood the questions, especially since the data were collected through online surveys. Self-reporting bias arises from factors such as social desirability, memory errors, respondent fatigue, and cultural differences, leading participants to provide inaccurate information. To mitigate this bias, researchers employ strategies like ensuring anonymity, using validated measurement scales, and employing diverse data collection methods. While complete elimination of self-reporting bias may be challenging, understanding its sources, and implementing appropriate methodologies can enhance the validity and reliability of survey findings. In this study context, validated questions used in the survey mitigate the bias. Furthermore, conducting interviews and observations were beneficial to compliment the survey data. This approach would allow participants to clarify any uncertainties and ensure that their responses align with the researchers' perspectives. Additionally, using open-ended questions instead of solely relying on closed-ended questions might provide deeper insights and more comprehensive answers from the participants.

6. Conclusion

This study reveals that the current work system for aging workforce can be cognitively straining, particularly concerning work system factors such as participants, information and task, and workplace and space. Specific conditions where aging workers felt cognitive strain included dealing with packed schedules, processing information both internally and externally, handling large amounts of data, and experiencing time pressure. Identifying these variables is crucial for effectively monitoring aging workers' well-being. It is essential to consider the declining cognitive function that comes with aging when designing interventions to support an aging workforce during these challenging conditions. This study provides valuable insights for engineering technology courses and capstone projects focused on designing and developing work systems that are more suitable for an aging workforce, which will assist organizations, businesses, and institutions in identifying risks and enhance overall work performance.

Acknowledgements

This work was supported by Ministry of Higher Education Malaysia under Fundamental Research Grant Scheme (FRGS/1/2022/TKl0/UPM/02/7).

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Appendix A

Survey Questionnaire – Section B (survey): Likert Scale

Strongly Disagree	Disagree	Neutral	Agree	Totally Agree
1	2	3	4	5

Work system related factors	**Questions**
Participants	My health condition is very good.
	I am physically and mentally exhausted.
	I have problem in handling client especially on online platform.
	My schedule is usually packed.

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Workplace and Space	My workplace is very comfortable
	My workplace facilities are well equipped.
	My computer set-up is updated.
	I often get injured at work.
	My back hurt whenever I work for a long period of time.
	My workplace is far from rest area (smoking area, toilet, canteen and etc).
Information and Task	My work involves processing complex information.
	My job requires memorizing a high amount of data.
	The pace of work is excessive, difficult to reach even by an experienced worker.
	My job requires no mistake.
	I often do not have time to complete all work tasks and have to do overtime.
	I want to improve my work performance.
Organization	Do you have the possibility of learning new things through your work?
	Does your colleagues or supervisor help you with your work?
	Does your company provide training on new technology?

Appendix B

Interview Questionnaire

Strongly Disagree	Disagree	Neutral	Agree	Totally Agree
1	2	3	4	5

Work system related factors	**Questions**	**Type of Questionnaire**
Participants	My health condition is very good.	Likert Scale
	At my work, I feel bursting with energy.	Likert Scale
	How often have you felt worn out?	Likert Scale
	How often have you been physically exhausted?	Likert Scale
	How often have you been emotionally exhausted?	Likert Scale
	How often have you felt tired?	Likert Scale
	How often have you had a headache?	Likert Scale
	I am physically and mentally exhausted.	Likert Scale
	My schedule is usually packed.	Likert Scale
	Describe your challenge when handling client.	Likert Scale
	How do you describe your health in previous 3 month? "visit doctor, hospitalized"	Likert Scale
Workplace and Space	My workplace is very comfortable.	Likert Scale
	My workplace facilities are well equipped	Likert Scale
	My computer setup is updated.	Likert Scale
	I often get injured at work	Likert Scale
	My back hurt whenever I work for a long period of time.	Likert Scale
	My workplace is far from rest area (smoking area, toilet, canteen and etc).	Likert Scale
	In your view, what changes can be done to make the workplace more age-friendly?	Likert Scale

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Information and Task	My job requires memorizing a high amount of data.	Likert Scale
	The pace of work is excessive, difficult to reach even by an experienced worker.	Likert Scale
	Is your workload unevenly distributed so it piles up?	Likert Scale
	Do you have enough time for your work tasks?	Likert Scale
	Do you have to do the same thing over and over again?	Likert Scale
	What is the most challenging task given to you?	Open-Ended Questions
	How do you describe your work routine?	Open-Ended Questions
	In your opinion what can be improve regarding work task assign to aging workers to make it more aging friendly.	Open-Ended Questions
Organization	In your opinion are you satisfied on your current company management?	Open-Ended Questions

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