Cognitive Ergonomics Analysis

Work environment of the Exterfer CEO

//EXTERFER

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Executive Summary

The modern workplace environment

It is important to recognise that the modern workplace environment is a source of unique cognitive strains that affect work productivity and performance. Research has demonstrated cognitive demands creating the cognitive load can result in exceeding the limits of human cognitive capacities.[1] The cognitive capacities are burdened further with unsatisfactory working conditions.

The cognitive ergonomics analysis (CErgA)

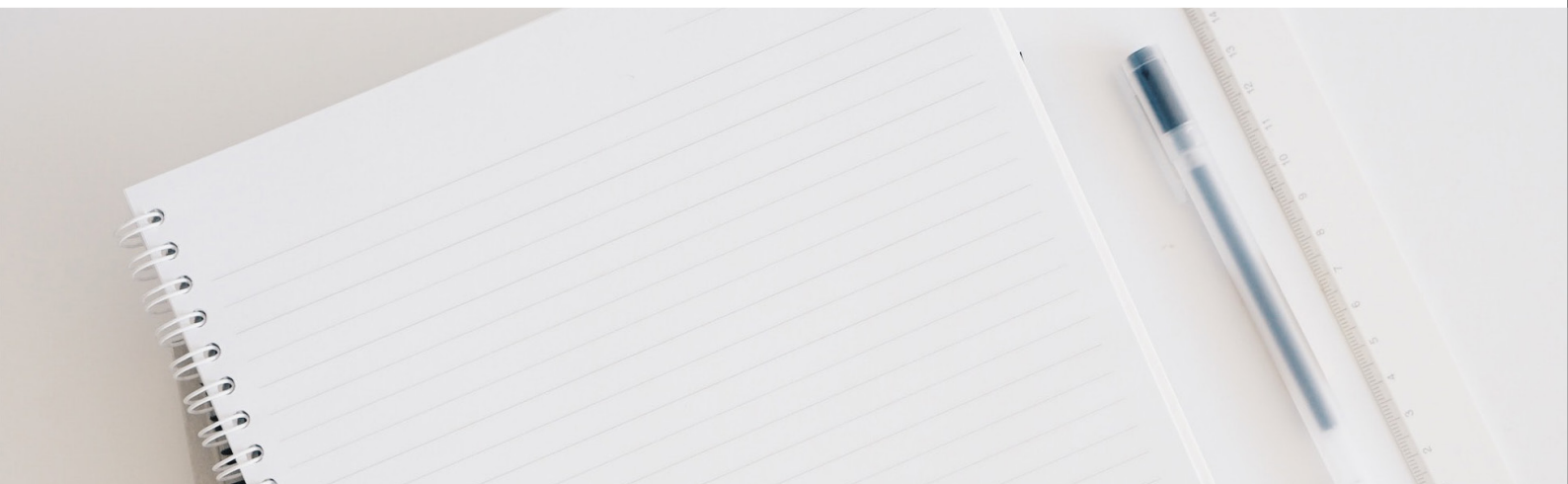
The workplace cognitive ergonomics analysis (CErgA) investigates human factors involved in 'appropriate interaction between work, product and environment, and human needs, capabilities, and limitations', as described by the Ergonomics and Human Factors Society.[2] The CErgA concentrates on knowledge-work office environments; it encompasses an analysis of work tasks that concern much of the office workforce.

Our main objective

Our main objective was to evaluate cognitive ergonomics at work, understand how they affect work performance and productivity and advise on solutions to enhance it. The focus was on cognitive functioning and the factors affecting it. We recognised 4 crucial work contexts/factors that impacted cognitive performance: 1. managing technology, 2. disruptions/interruptions, 3. physical and digital environment, 4. lifestyle.

Higlights

In the report we highlight that conditions in work environments are complex. The disruptions, interruptions, information overload, and other human factors are all connected. It is also all a part of a whole work ecosystem rather than just one individual. Therefore, we propose some simple solutions such as: implementing a quiet hour, changing organization of notes and making healthy food salient as possible intervention to improve cognitive performance. However we emphasize that effective intervention is likely to require a joint effort rather than just adjusting the actions of one employee.



Introduction

Modern workplace environment

We recognise that in the current predominantly digitised work environments, to perform work tasks one has to rely heavily on cognitive functioning.[3] Cognitive functioning refers to all the processes involved in information processing, such as attention, working memory, decision-making, and learning.[4] All these processes are the most common cognitive demands of modern knowledge-based jobs, which deal with acquiring, creating, and applying knowledge, as well as continuous on-the-job learning.[5]

Cognitive demand and cognitive load

In this report we use two important psychological concepts called "cognitive demand" and "cognitive load."

Cognitive demand relates to how intellectually challenging a work task is.[6] People face various cognitively demanding tasks in their job roles. Completing a task can either require multiple cognitive processes, switching between these processes, or only one process that is automatic. The higher the cognitive demand of the task, the more cognitive resources need to be used.

Cognitive load refers to information that has to be maintained in one's mind when completing a particular task.[7] For example, to solve a problem at work, we need to keep in mind the information about the problem, as well as the goal, and possible strategies to solve it. To maintain this information, we use the working memory.

Exceeding the cognitive load

The cognitive load is caused by the cognitive demands of work tasks. And due to the nature of modern work, cognitive load tends to exceed human cognitive capacities. In addition, the cognitive capacities may be strained further with poor working conditions.

What is a CErgA?

The two concepts we described are crucial in understanding the cognitive ergonomics analysis (CErgA). In a CErgA we observe and investigate the nature of the employee's tasks. We evaluate the cognitive demands and the cognitive load of all tasks the employee needs to accomplish in their role. By using the CErgA approach, we can better understand how a person operates within their role and can consult them on what changes to implement to improve their work performance.[8] Suggested changes can vary from offering altering the physical set-up of the workspace to changing lifestyle habits.

Performing CErgA at Exterfer

Our CErgA was performed to improve the work performance of a CEO in the supply chain business. His work is mainly office-based and relies heavily on technology. It also involves mental tasks performed out of the office, e.g. conversations with warehouse managers, evaluating and progressing production lines.

To relay a clear picture of our CErgA, in the following sections we first describe the cognitive demands of the modern workspace. Followed by the job-related tasks we observed and the cognitive demands related to it. We then move onto our specific case and our method. Finally, we present our results and conclusions.

The 4 work contexts

The four most common contexts in which cognitive performance is affected by its environment and other human factors.

1. Work and technology

2. Disruptions and interruptions

3. Workspace environment

4. Lifestyle

+ contexts

01	*Work & Technology*	Information overload (working memory, attention and multitasking)
02	*Disruptions & Interruptions*	Non-priority tasks, noise, co-workers-habits
03	*Workspace environment*	Plants & greenery, tidiness, organization, convenience
04	*Lifestyle*	Sleep, food, exercise, social-life

1. Work and technology

Technology has changed the way we live and work. A positive impact of technology is that time managing tools and many other helpful applications have reduced cognitive load for many job tasks.[9] For example, we do not have to do mental mathematics anymore or memorize dates or phone numbers. Technology has also enabled us to grow our networks through a large variety of communication tools (e.g. email, video calls). However, it has become evident that the use of technology has some downsides too. Excessive use of technology has been found to lead to mental fatigue, decreased performance, and inhibition of creativity. [10]

We have become very reliant on technology. Computers and other devices have become invaluable. Next to hardware, conducting business is almost impossible without the appropriate software and the internet.

In addition, most people cannot work without their mobile devices, which are devices used both for work and for leisure activities (e.g., mobile games). Because of technological dependence, any technological malfunctions can become a big stressor and a distraction in everyday life.[11] In our analysis, we observed that if technological issues arise at work, they create significant uncertainty. In the interview, it was reported that technological issues tend to impair the performance of most employees. The disruption to their flow causes stress because urgent tasks are delayed. Research has shown that such drastic interruptions of work not only impair the task at hand but productivity for the rest of the day. [12]

2. Disruptions and interruptions

It is not only technology that creates disruptions. Speech, music, and other office noises have been found to disrupt work-related tasks.[13] Interruptive sounds have an impact on sequential processing, which is a crucial mental activity for most work tasks.[14] Therefore, interruptions can have harmful consequences on task performance.

We observed that sequential processing tasks (e.g writing offers, answering emails, talking to clients), which need full attention for a continuous amount of time, are best completed when there are no distractions or interruptions from other employees. Research has shown the same effect: being free of any disruptions enables employees to focus better.[15] This leads to improved performance on the task at hand but moreover in overall day-level performance.[16]

Information overload, multitasking, task switch and working memory

It has also been shown that employees performing modern, knowledge-based work suffer from disruptions that create information overload and lead to multitasking.[17] It all comes down to our limited capacity for information processing: our cognition is limited due to the amount of information it can maintain at the centre of attention and the limited working memory capacity. Working memory capacity is on average four items. Without immediate practice, information leaves the working memory in less than 30 seconds. [18] We observed that when the CEO had to search for specific information whilst communicating on the phone, he reverted to multitasking. In the interview, he reported that sometimes when he multitasks, he ends up making mistakes and giving wrong information about products, which can negatively impact the sales process. Multitasking creates frequent task switching, which increases the likelihood of human errors such as slips and lapses. A slip is a failure during the execution of a task and a lapse is a working memory failure. Both impair cognitive performance. [19 20 21]

Limited capacity

Because there is a limited capacity to remember and process all the information we go through, we require a good system for storing information elsewhere than in our heads. In most work settings, people use various tools to remember important information. For example, they set reminders, highlight events in their calendar, and use notes. Research has demonstrated that better practices for managing new emails and notifications can reduce information overload and stress. [22] For instance, checking emails less often and at specific times during the day (rather than anytime or all the time) results in lower stress levels. Applying this method led to increased perceived productivity. [23]

3. Workspace environment

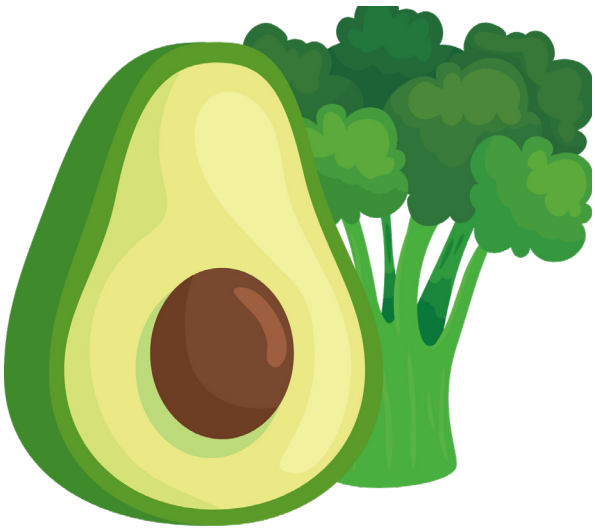
We observed that there are two distinct workspace environments. There is a digital environment, which encomapsses quantity and variety of windows open on one's screen, as well as the general organisation of all windows. And there is a physical environment, which includes factors such as lighting (room and screen brightness), chair and screen position, tidiness, and other physical factors influencing work performance. Both environments are equally important, as they both can either enhance or impair task performance. [24]

Visual search

In our analysis, we noticed that the CEO had many tasks involving visual search. This visual search was impaired by two main factors. One was desk clutter: multiple papers with no organisational system. The other factor was interaction technology interruptions (calls, emails). Both factors appeared to be the result of a lack of digital and physical environment organisation. For example, email notifications were not managed to help sustain attention for a long period of time and the paper clutter made it difficult to find necessary information. Organised environments can reduce the cognitive demand of visual search and result in better work performance. Research shows that managing the workspace environment improves efficiency and productivity.[25]

4. Lifestyle and work

Research shows that for cognitive functioning to reach its peak performance level, the brain needs to be healthy. A healthy brain has sufficient blood flow, which brings the oxygen and energy that are crucial to its functioning. [26] In addition, it is important that other problematic processes, such as inflammation, are not occurring anywhere in the body. A healthy brain depends partly on genetics, but mainly on lifestyle. Research is in support of regular aerobic exercise, which has been found to increase blood flow to the brain, which improves overall cognitive functioning.[27] In addition, aerobic exercise is a predictor of healthy cognitive ageing. Research also suggests a healthy diet leads to a healthy brain.[28] Eating foods rich in minerals, vitamins, essential fatty acids, and proteins stimulates neural growth and protection. Eating healthy foods not only affects the brain directly, but also decreases inflammation in other organ systems.



It was observed that the CEO often had to prioritise work over having lunch at the appropriate time. This resulted in him postponing his healthy lunch and eating unhealthy snacks instead. He chose these unhealthy snacks because they were easy and quick to consume. Thus allowing the completion of the prioritized work tasks without much interference.

Importance of CErgA

It has been shown that cognitive strains related to work demands or working conditions are a risk factor for work performance, as they directly affect the ability to successfully complete cognitively demanding work tasks. [1] These demands and work conditions not only hinder specific task performance, but also lead to cognitive failures that affect broader work performance. Analyzing and improving cognitive ergonomics can have a significant impact on a person's work performance and well-being. Therefore, it is essential to manage cognitively straining conditions and reduce their harmful consequences for individual employees, teams, and organizations. Research has shown that high work performance and high employee well-being go hand-in-hand, along with support from good working conditions.[1 29]

Dut to the reasons described above, our focus is on analyzing and improving practices to improve work performance. Put simply, the purpose of workplace ergonomics is to create a better workplace. Since a better workplace results in improved work quality and a better experience for the employee, improving cognitive performance has great value for both the employee and the business. To conclude, all consulting is done with one main objective: Achieving optimal use and division of cognitive resources to improve work performance.

Our focus

In sum, our study has analysed the related factors and has devised intervention strategies that aim to reduce cognitive strain at work. Our aim was to answer the following two questions:

1. What tasks are the most and least cognitively straining tasks for the CEO and why?

2. What can be changed to improve workflow, performance, and well-being?

Methods

Definition

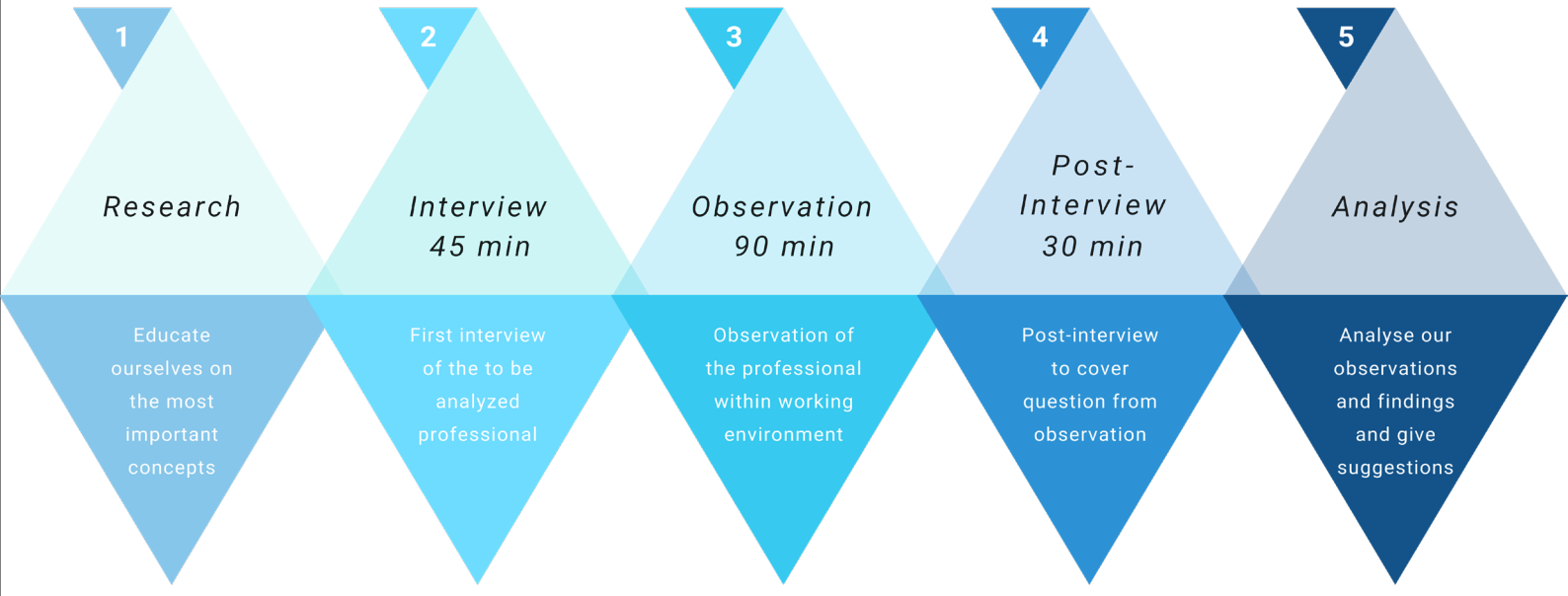
We define cognitive ergonomics in the context of office-work and focus on the factors that reduce the cognitive strain related to working conditions. Our analysis and method specifically targets the general population in offices and broadens our understanding of both their cognitively intensive tasks and their cognitively demanding working conditions. We based our study on past research that focused on improving cognitive performance at work.

About UH

UH is the CEO of a company that does wholesale trade of steel and steel products. He has a vast array of tasks he needs to perform as the CEO: he needs to make decisions about the future of the company, maintain relationships with clients, oversee product orders, and manage the employees who supervise production. In more practical terms, a day in the office mainly involves sitting behind a laptop, making phone calls, participating in office meetings, and occasionally going to the warehouse to check on production.

Interview

To answer our questions, we designed and conducted a semi-structured interview. Before the interview, we analysed the usual job requirements of a CEO position in a supply chain business. Then we combined this knowledge with the literature research and developed questions and conversation starters to draw information from the interviewee. Depending on how UH answered, we asked some follow up questions to gain a more in-depth understanding of his work tasks and factors that may affect his work performance.



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Observation

We conducted an in-person observation for 90 minutes. The participant showed the observer how they completed their everyday tasks. The observer also took pictures of UH's workspace for reference.

Post-Interview

We conducted a post-interview to get feedback from UH about our proposed solutions to the problems we identified.

Process

Once the interview and observation were completed, our team went over all the information that had been gathered and pin-pointed the areas that could be improved. During a second, post-observation interview, we gathered any information we had not yet been able to acquire. The steps involved in the above-mentioned processes will be described fully and in detail in the following paragraphs.

During the first interview, UH was asked about many factors that may have an effect on his cognitive functioning at work, along with general information about his tasks within the company and his typical work day. He described his system for organizing information and tasks, how efficient his memory is for work tasks, how he spends his breaks, and his eating and sleeping habits.

In the observation phase, which took 90 minutes, a team member observed UH while he was working in the office. UH's work desk was crowded by a large number of papers, including envelopes on which he took notes. He was interrupted very often by either phone calls or by employees coming in to ask questions. He took frequent breaks, during which he walked over to the warehouse, smoked a cigar, and spoke to the manager of the warehouse.

After the data collection phase, we focused on applying our knowledge about cognitive psychology to identify distractors and create solutions to optimize UH's work space. Our aim through this process was to make UH's work environment as compatible as possible with optimal cognitive functioning. Thus, by using cognitive knowledge and tools, we want to change UH's environment to enhance his cognitive performance. We aimed to find solutions which are simple to apply, such as better organizational systems and healthier eating habits.

Results

During our observation we discovered various factors that could negatively impact the overall performance of UH. These factors are switch costs, work environment, and lifestyle, which are described in detail in the following sections.

ManagingTechnology

Disruptions and impaired memory performance due to communication technologies

Working memory is used when one has to remember and use relevant information while engaged in an activity. For example, if a client on the phone asks for product dimensions or prices, UH must answer as quickly as possible. Even if he does not have the information readily available (in working memory), he must remember where the information can be found. If he is interrupted during the search for information, either by the caller or by notifications, this impairs the sustained attention needed for information search.[30] It was observed that UH experiences a lot of disruption from interaction technologies (e.g. emails, phone calls, skype) that cause information overload that disrupts task performance. [31 32] Our observation and interview results show that information overload due to communication technologies leads to multitasking and forgetfulness, which impair both specific tasks and overall performance.

UH stated that errors and omissions result in missing deadlines, unless others remind him of the information he has forgotten.

Disruptions and interruptions

Switch costs and distractions due to frequent calls and employee visits

As outlined in the introduction, switching between tasks frequently is cognitively demanding. [17 33] Thus, doing so often within a short time-period can lead to exhaustion. Furthermore, constant task switching increases the likelihood of human errors such as slips and lapses.[34] During our interview with UH, it became clear that due to the nature of his position as CEO, he frequently has to switch between his office tasks and incoming customer calls or inquiries from his employees. More concretely, he gets interrupted while answering emails or looking at the current financial situation of the company by incoming calls and by employees who enter his office to ask questions. UH added that this occurs very frequently throughout the day.

We theorize that this frequent switching between tasks results in high cognitive load, which is mostly due to switching costs rather than the cognitive demands of productive task completion. Since the CEO switches between tasks that rely on different modalities, his switching costs are even higher. [17] When looking at graphs and financial figures, UH relies on spatial resources, but has to switch to verbal resources when answering calls or talking to employees. Furthermore, he switches between the use of perception and cognition when reading through emails and orders from clients, and response and action when making decisions about employees or customer matters.

+ results

Workspace environment

Prolonged visual search due to paper clutter on desk

We observed that UH has too much paper on his desk. He reported that his habit is to take notes on any piece of paper that is available. This might be the empty side of a printed customer order or the blank space on an envelope. While this style of note-taking might be convenient, it leads to an overload of visual clutter on his desk and makes finding specific notes among many others very cumbersome.

We theorize that this lack of organized note-taking results in regular prolonged visual search activities and is cognitively demanding due to the high amount of distractors (other papers), which need to be suppressed to focus on finding the target note. [35] Additionally, the time spent on visual search could be used for productive activities if UH's notes are more organized and easy to find.

Remote phone charger leads to frequent disruptions of focused work

UH reported using his mobile phone extensively during work hours. His smartphone is an important tool in his role as CEO. Due to this extensive use, it runs out of charge at an increased rate and must be recharged once or even multiple times per day. During our observation, we discovered that the phone charger is located on the other side of UH's office. Thus, he needs to stop his work, get up from his desk, and walk to the charger to plug in his phone. As such, the necessity of charging his phone has multiple implications: (1) UH must interrupt his workflow to plug in his phone. This regular distraction and the need to stop and resume the task at hand results in a loss of focus, and thus decreased productivity and an increase in the likelihood of slips and lapses when resuming [36]. (2) The time spent standing up, walking to the other side of the room, returning to his desk, and resuming his task adds up. These minutes could be spent on more productive tasks. (3) UH is unable to properly use his phone while it is charging. If he gets a call while the phone is charging, he again needs to interrupt his work to go to the phone to answer it.

In light of the reasons above, we propose installing a charging port that is in close proximity to UH's desk. This port should be within one arm's length.

Lifestyle and work

Regular consumption of sugary snacks leads to varying blood sugar and brain glucose levels

The interview with UH revealed that on busy days he regularly delays lunch and instead eats sugary snacks. These snacks are stored in a cupboard near his desk and are meant to be offered to customers. However, the availability and ease of consumption makes UH choose snacks rather than having regular healthy meals. While the regular consumption of sugar might have long-term implications on overall health, such as obesity and increased risk of diabetes, it may also have significant short-term influences on blood sugar levels and thus cognitive performance [37]. Research has shown that an unhealthy diet consisting of many processed foods and sugars has a negative influence on mood, memory, and even long-term cognitive health. [38] Additionally, the highs and lows in blood sugar due to the high fructose content in snacks lead to a strong variance in cognitive performance throughout the day compared to the more stable sugar release of healthy carbohydrates. [39]

For the reasons stated above, we propose a healthier snack alternative or a more regular consumption of meals. This could improve the attention, memory, and mood of UH, which would lead to higher productivity and potentially less slips and lapses throughout the workday.

Conclusion

Our CErgA focused on a knowledge-work office environment and covered work tasks that are applicable to many other people who work in offices. Therefore, we believe our findings are generalizable to other knowledge-work office environments.

Our advice

Through analyzing the interview and observation, we found that many of the cognitive ergonomics concerns described in the results overlap. We drew similar conclusions as previous research has done. Disruptions were found to be a general issue to the workflow. They also lead to information overload, which causes cognitive load because the information exceeds our cognitive processing limitations. There are disruptions, which stem from poor management of technological communications, and interruptions from the physical environment.

Past research strongly indicates that exposing workers to cognitively straining conditions has detrimental effects on task performance, overall productivity, and may impair occupational safety and health. Therefore, to avoid the possible negative effects, we propose the following solutions to alleviate cognitive strains that UH experiences at the workplace.

Having a quiet hour

During the observation, we found that attention and flow are impaired mainly by interruptions. Having a "quiet hour" free of disruptions has been shown to help with completion of tasks that require sustained attention. In the interview, UH confirmed that he tends to complete such tasks at home because at work there are always interruptions. We suggest he implements a "quiet hour" at work, so he can achieve the same productivity he achieves at home. For example, notifying all employees that he should not be disturbed from 9.00 to 10.00.

We also advise that he turn off notifications and silence his phone for that hour. This should help him achieve similar levels of productivity as at home. Our other suggestion to reduce daily disruptions is for employees to collect several questions and ask them in one go instead of asking them one by one as they arise throughout the day. Research has shown that this method increases the efficiency of helping and sharing knowledge between employees.

Re-organising physical and digital environment

To reduce errors and forgetfulness caused by multitasking, we suggest implementing a new note-taking system. We recommend using a note-taking software to take and access notes for email and phone communications. This could lead to reduced paper clutter, which is a related issue. In discussion with UH, we found that he liked the suggestion.

+ conclusion

However, he was on the fence because he has been taking notes the same way for 20 years, and thus is reluctant to commit to change. Accordingly, our second recommendation did not involve changing UH's note-taking system. We suggested that UH use a paper basket to dispose of paper he no longer needs. The paper in the basket will be shredded by an employee before it is binned. This way UH will keep only necessary papers on his desk and get rid of the rest.

Increasing visibility and availability of healthy snacks

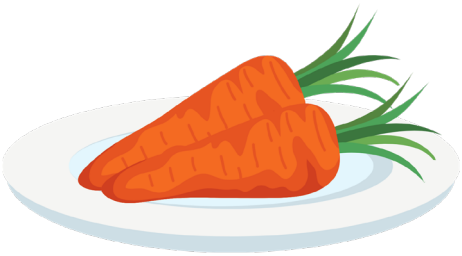
It As proposed in the results, UH would benefit from healthier snack alternatives or maintaining regular meals. When discussing this problem with UH, we understood that the work is too varied to maintain regular meals. We also understood that he likes healthy snacks and they have them in the office. However, he reverts to unhealthy ones because they are more convenient. In accordance, the best solution might be making healthy snacks (fruit & nuts) more visible and more convenient to access than unhealthy ones.

Important factors in implementing changes

Past research has indicated that successful implementation of changes depends on employee commitment, timely support from other employees, supply of information, expert support, and understanding the implications of implementing changes. For example, when we suggest implementing a change in UH's daily routine, such as "quiet time," this would affect all other employees. In order to overcome differences in schedules, it is essential to involve everyone concerned in the planning stage.

Another important thing to factor in before implementing changes is if the change is feasible for this specific individual. For example, professionals such as UH, who have worked in their own way for 20 years, will have very specific preferences and ingrained habits that are challenging to change. Therefore, our focus was on factors that UH had intrinsic motivation to change and on factors where the benefits would clearly outweigh the costs (effort) of change.

We conclude that it is important to take into account the individual's wishes and capabilities, as well as the entire work ecosystem when recommending and implementing changes.



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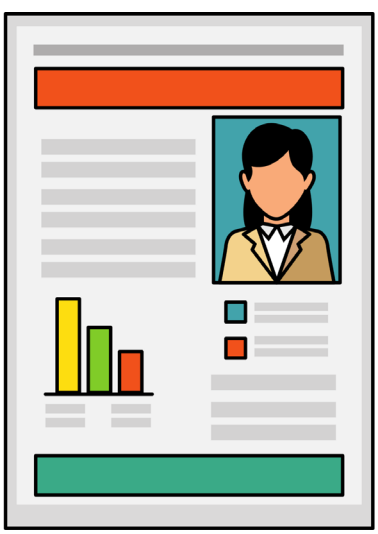
CErgA Reliability

We believe our findings are reliable, as we three expert researchers drew similar conclusions regarding the cognitive workplace performance of UH. Our approach was scientific. Reliability may be slightly impaired due to UH acting differently under observation. He could have been nervous or distracted by the presence of a researcher, which could have led him to not complete tasks as he normally would. In addition, we must note that based on the information provided in the interview, UH's workdays vary significantly. With the interview and 90 min observation we managed to gain a brief understanding of the cognitive demands and cognitive load of this particular job. However, previous research highlights that this may not be enough, as this is just one unit that is a part of a large business ecosystem. There may be important factors that we missed by focusing only on one employee rather than the whole department. Thus, we took caution when proposing our solutions and discussed them with the individual before writing this report.



We also recognise that a limitation of our method is that none of the factors observed are objectively measured. We recognized and evaluated performance issues based on our speculations, which are based on our expertise and past literature. There are many pros but also some cons to this method. The CErgA method is quicker and cheaper than longitudinal research, as this requires designing measuring tools first and then implementing them. In addition, through real-time observations, we are able to detect factors that a measurement tool may miss. The main downside of this method is its susceptibility to wrong interpretations. Because there is only one observation, there is a chance it is not representative of a typical workday. Incorrect interpretations following the one-time analysis and inappropriate solutions can hinder work performance instead of improving it. However, to avoid this downside, we make sure the observations match what the employee self-reports in the interview and confirms in the post-interview. The method could be further improved by adding an objective measurement of performance on the work tasks.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