



**Vaasan yliopisto**  
UNIVERSITY OF VAASA

Juho-Matti Samuel Veteläinen

**The link between cognitive strain and ability to  
perform well in the knowledge work**

School of Technology and Innovations  
Master's thesis in Economics and  
Business Administration  
Industrial Management

Vaasa 2023

---

**UNIVERSITY OF VAASA****School of Technology and Innovations**

<b>Author:</b>	Juho-Matti Samuel Veteläinen
<b>Title of the Thesis:</b>	The link between cognitive strain and ability to perform well in the knowledge work
<b>Degree:</b>	Master's in Economics and Business Administration
<b>Programme:</b>	Industrial Management
<b>Supervisor:</b>	Binod Timilsina
<b>Year:</b>	2023 <b>Pages:</b> 84

---

**ABSTRACT :**

Working life has changed quite rapidly from manual work to knowledge work in the past decades. Due to the transition, companies are facing new kinds of challenges what comes to overall employee wellbeing. From the working ergonomics point of view the focus should be widened from the physical working ergonomics perspective also to cover the cognitive ergonomics, which is the most effective aspect of ergonomics for the knowledge workers, in a knowledge-intensive organizations. And as talking about the knowledge work, the cognitive strain has impacts on the working performance of knowledge workers.

In this research, the goal is to build the link between the cognitive strain, and ability to perform well in the knowledge work. The study also aims to research cognitive ergonomics and how it could help in mitigating cognitive strain and enable knowledge workers to perform well. The cognitive strain has been observed via various factors of interruptions, disruptions, and information overload. Knowledge work performance has been defined based on the sources in the theory background as well as from the case company defined performance factors.

The study findings show that the cognitive strain has an impact on the employee's performance based on their own evaluation. The information overload was experienced as the most challenging, interruptions as secondly, and disruptions as the least severe source of cognitive strain. Also, cognitive ergonomics is seen as an interesting, but not so well-known topic among the interviewee respondents. The employees had built their own routines to mitigate the cognitive strain, but organizational-wide guidelines, for example for the remote work, would be appreciated by the interview respondents.

The study contains solid theoretical background of the topic and extensive interview results, which leads to the discussions about the potential solutions to developing the cognitive ergonomics in the organization as well as suggestions for the future research identified during the study.

---

**KEYWORDS:** Cognitive strain, cognitive ergonomics, knowledge work, work performance

---

**VAASAN YLIOPISTO****Tekniikan ja innovaatiojohtamisen yksikkö**

<b>Tekijä:</b>	Juho-Matti Samuel Veteläinen
<b>Tutkielman nimi:</b>	The link between cognitive strain and ability to perform well in the knowledge work
<b>Tutkinto:</b>	Kauppatieteiden maisteri
<b>Oppiaine:</b>	Tuotantotalous
<b>Työn ohjaaja:</b>	Binod Timilsina
<b>Valmistumisvuosi:</b>	2023 <b>Sivumäärä:</b> 84

---

**TIIVISTELMÄ :**

Työelämän muutos manuaalisesta työstä kohti tietotyöyhteiskuntaa on ollut nopeaa viime vuosikymmeninä. Nopean muutoksen vuoksi yritykset kohtaavat uudenlaisia haasteita työntekijöiden hyvinvointiin liittyen. Kokonaisvaltaisen työergonomian näkökulmasta tarkastelukulmaa olisi syytä laajentaa fyysisen ergonomian huomioimisesta myös kognitiivisen ergonomiaan, mikä on tärkeintä tietotyöntekijöille, jotka työskentelevät osaamisintensiivissä organisaatioissa. Tietotyön kontekstissa kognitiivisella kuormituksella on vaikutuksia työntekijöiden työssä suoriutumiseen.

Tässä Pro Gradu -tutkielmassa tavoitteena on yhdistää tietoa kognitiivisesta kuormituksesta sekä hyvästä suoriutumisesta tietotyössä. Tutkielma pyrkii myös selvittämään kognitiivisen ergonomian keinoja auttaa vähentämään kognitiivista kuormitusta ja edesauttaa tietotyöntekijöitä suoriutumaan hyvin työssään. Tutkielmassa kognitiivista kuormitusta on tarkasteltu keskeytysten, häiriötekijöiden ja tietotulvan eri konkreettisten ilmenemismuotojen kautta. Tietotyössä suoriutumisen määritelmä on tehty teoriataustassa käytettyjen lähteiden, sekä case-yritykselle toteutettujen haastattelujen vastausten perusteella.

Tutkielman tulokset osoittavat, että haastateltujen tietotyöntekijöiden arvioiden mukaan kognitiivisella kuormituksella on vaikutusta työntekijöiden työssä suoriutumiseen. Haastateltavien keskuudessa tietotulva koettiin kaikkein ongelmallisimmaksi, keskeytykset toiseksi, ja häiriötekijät vähiten ongelmalliseksi kognitiivisen kuormituksen ilmenemismuodoksi. Kognitiivisen ergonomian käsite koettiin myös hyvin kiinnostavaksi haastateltavien keskuudessa, vaikka aihepiiri ei ollut entuudestaan tuttu. Haastateltavat tietotyöntekijät olivat rakentaneet omia rutiineita kognitiivisen kuormituksen ehkäisemiseksi, mutta koko organisaation kattava ohjeistus, esimerkiksi etätöyöhön, olisi tervetullut haastateltavien näkökulmasta.

Tutkielma koostuu teoriataustasta ja laajasta haastattelumateriaalista tuloksineen, joka johtaa pohdintaan mahdollisista ratkaisumalleista, joilla kehittää kognitiivisen ergonomian tasoa organisaatiossa. Tutkielman lopuksi on vielä jatkotutkimusehdotuksia, joita on tunnistettu tutkimusta tehdessä.

---

**AVAINSANAT:** Cognitive strain, cognitive ergonomics, knowledge work, work performance

## Contents

1	Introduction	7
1.1	Background	7
1.2	Terms and definitions	9
1.2.1	Knowledge work and performance	9
1.2.2	Cognitive strain	10
1.2.3	Cognitive ergonomics	11
1.2.4	Other relevant terms and definitions	12
1.3	Research objectives and questions	13
1.4	Limitations	14
1.5	Structure of the thesis	15
2	Background of the case company	16
3	Theoretical background	18
3.1	Performance in the knowledge work	18
3.2	Cognitive strain in the knowledge work	21
3.2.1	Disruptions	22
3.2.2	Interruptions	22
3.2.3	Information overload	23
3.3	Cognitive ergonomics in the knowledge work	24
4	Methodology	27
4.1	Research philosophy	27
4.2	Research approach	29
4.3	Research method	30
4.4	Data collection and sample	31
4.5	Data analysis	32
4.6	Trustworthiness of the study	33
5	Results and Analysis	35
5.1	Work performance in the case company point of view	36
5.1.1	Performance definition	36

5.1.2	Performance measurement	37
5.1.3	Performance management	38
5.1.4	Managerial challenge to performance evaluation, follow-up, and management	40
5.2	Cognitive strain in the knowledge worker's point of view	41
5.2.1	Disruptions	42
5.2.2	Interruptions	43
5.2.3	Information overload	46
5.2.4	Affects of cognitive strain	48
5.2.5	Cognitive strain and work performance	49
5.3	The role of cognitive ergonomics in the knowledge work	51
5.3.1	Cognitive ergonomics & self-leading skills	51
5.3.2	Organization role in the cognitive ergonomics	54
5.4	Summary of key findings	57
5.4.1	Theme mapping	58
6	Discussions and Conclusions	62
6.1	Discussions on the results and findings	62
6.1.1	Definitions and factors of a good performance level	62
6.1.2	Cognitive strain and ways to maintain cognitive ergonomics	64
6.1.3	Affects of cognitive strain on knowledge work performance	67
6.2	Suggestions for future research	69
6.3	Practical implications	71
6.4	Conclusion	76
	References	77
	Appendices	82
	Appendix 1. Managerial interview setup; "work performance in the case company point of view"	82
	Appendix 2. Knowledge worker interview setup; "Cognitive strain in the knowledge worker's point of view"	83

## Figures

Figure 1: The Yerkes & Dodson law, 1908 from Gino (2016)	12
Figure 2: Thesis structure	15
Figure 3: Company high-level organization structure	17
Figure 4: Knowledge work performance definition according to Palvalin et al. (2015)	20
Figure 5: Cognitive strain concept definition based on Kalakoski et al. (2020)	21
Figure 6: Cognitive ergonomics factors figure based on Muistiliitto (2023)	24
Figure 7: Interview theme map	61
Figure 8: Research questions map	68
Figure 9: Roadmap for cognitively sustainable organization	75

## Tables

Table 1: Other relevant concepts and definitions	12
Table 2: Interview respondents from the management	36
Table 3: Interview respondents	41
Table 4: Identified themes from interviews	57

# 1 Introduction

## 1.1 Background

Finland, as many of the other countries has changed quite rapidly in the past decades from the blue-collar labor work-based society to a white-collar, knowledge-intensive work-based society. Furthermore, the past years have changed the working culture of knowledge work, the location free working has become very popular among the companies as well as working in a distant team in a distributed organization model. There is still a lot to be learned about the knowledge work as well as location free working what comes to the employee well-being, cognitive sustainability, and performance management. This research aims to study this entity from the cognitive strain and employee performance point of view.

Following the news and general discussion around leadership and performance management, the risks of cognitive strain have been quite popular in the past few years. The interest in developing cognitive ergonomics for employees, in work and off the work, has been notable. It is very important for the general well-being of the employees, but also from the business perspective, to keep in mind that the people doing well are performing well. So, there are reasons to invest time and resources in research and development of this topic.

What comes to the research field, there have been quite a lot of reports regarding a large number of information people are required to process nowadays (Roetzel, 2019). Keeping in mind the fact that human information-processing principles and the brain structures have remained the same for at least 30 000 years, the need for studying the overall ergonomics of the employees in an ever-changing, modern working life is underlined (Kalakoski, 2019).

The scientific research around cognitive ergonomics in working life has traditionally been focused on a narrow context, for example in demanding dynamic tasks such as air traffic control and healthcare environment (Kalakoski, 2019). That means the concept of cognitive ergonomics is used in specific environments that are not directly applicable to other contexts. There is a need to expand the knowledge of human cognitive functions and clarify clear definitions of cognitive

aspects on a general level in the modern knowledge-intensive working life. Terminology and the general context need standardization.

There are various factors that have an impact on cognitive balance and the purpose of this paper is to gain an understanding of the factors creating a cognitive strain, how the cognitive strain affects to the employees generally and their ability to perform well, and which kind of activities could be useful to enhance the cognitive ergonomics, which would lead to a better well-being and enhance the ability to perform well in the work. This research also studies the definition of the performance factors in the knowledge work, which creates the base to understand the cognitive strain effects on the identified factors. As it is found out, knowledge work is cognitively demanding, and mental overload has been identified to have impacts on individual and company level performance (Kalakoski et al., 2020).

In the industry field there is need to raise awareness for studying human centricity. As in the case company of this thesis, the knowledge worker employees are the most valuable asset of the knowledge-intensive organizations and without them, running a sustainably profitable business would not be possible. As people are the key assets, with the success factors, the asset management activities should be directed primarily towards the employees of the organization.



## **1.2 Terms and definitions**

### **1.2.1 Knowledge work and performance**

A knowledge worker is a person who works primarily with information, knowledge worker develops and uses knowledge at the workplace (Palvalin, Vuolle, Jääskeläinen, Laihonen, & Lönnqvist, 2015). Knowledge work is defined in many ways, but there is no standardized definition for it, however, the characteristics of knowledge work are identified, known as high degree of expertise, education or experience, and the primary purpose of knowledge work involves the creation, distribution or applying of knowledge (Jääskeläinen & Laihonen, 2013).

Knowledge work requires a high degree of self-organization abilities by the employees, work tasks can vary, and the work structure is open, as well as the work is usually performed outside of the direct supervision of management (Costas & Kärreman, 2016). In knowledge work the specific expertise of the workforce is the main resource, knowledge workers are usually qualified individuals. Knowledge work nature is related to creativity, problem-solving, and task complexity instead of routine tasks or strict work processes or structures.

The value in knowledge work is created through knowledge rather than monotonous labor, tasks are complex with a large amount of variety (Pyöriä, 2005). Levels of autonomy and independence are required in daily operations. Knowledge work usually also requires continuous on-the-job learning and creating and applying knowledge.

### 1.2.2 Cognitive strain

Cognitive strain is usually a personal experience, and it can vary depending on the individual situation (Muistiliitto, 2023). Cognitive strain is not always caused by the amount of work or by effects of the working environment, but personal needs, feelings, motivations, personality, personal reactions towards challenges and stress. Also, more tangibly the individuals age, mental balance, health, usage of alcohol, food diet and physical activity.

However, cognitive strain related to the knowledge work depends on the work structure setting and the circumstances of the work (Kalakoski et al., 2020, p. 14). Cognitive strain is a risk factor for work performance as it affects the human ability to contribute to cognitively demanding work tasks. In general, scientific research has identified three categories for cognitive strain: disruptions, interruptions, and information overload which includes different factors depending on the working environment, organizational setting, organization culture and so on.

Disruptions can be considered things such as disruptive noise or speech in the office environment (Röer, Bell & Buchner, 2014). Interruptions then are a stoppage of an activity caused by, for example, people asking help in an open-office setting (Couffe & Michael, 2017). Information overload can be caused by multitasking and endless notifications and information via interaction technologies (Duggan, Johnson & Sørli, 2013; Sykes, 2011)

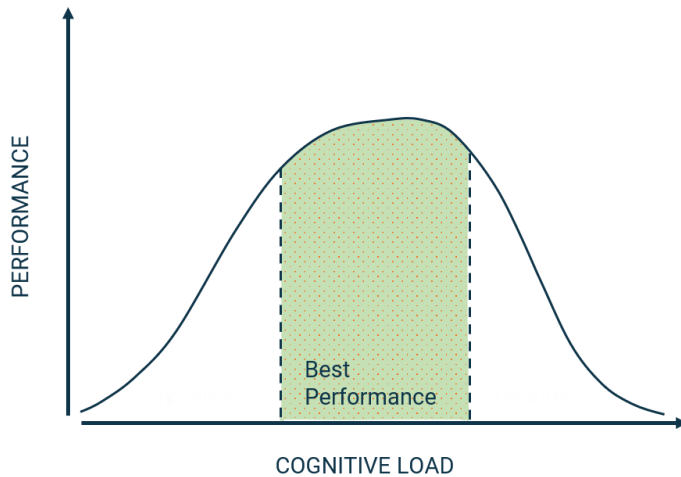
### 1.2.3 Cognitive ergonomics

Cognitive ergonomics focuses on the cognitive side of work (Työterveyslaitos, 2023). Sustaining cognitive load requires both the organization and the individual employee to reduce the cognitive strain and its sources and help the employee to succeed in the work tasks. The aim of cognitive ergonomics is to craft the work towards more fluent, riskless, and less stressful direction (Paajanen & Kalakoski, 2017). In cognitive ergonomics development, the cognitive strain factors are mapped out and identified, and further on, reduced and mitigated to reach a better working environment for the employees, where they can feel well and flourish in work.

In the cognitive ergonomics, considered factors are mental processes, such as perception, memory, reasoning, and decision making in the circumstances of interaction between human beings and human and other elements of the social settings (International Ergonomics Association, 2011). Practical factors related to cognitive ergonomics and cognitive capability are mental load, decision making, performance, human-machine interaction, stress, and education. Solutions for reducing the cognitive load can be for instance the rules at the workplace how and when to contact each other, well-defined structure for information distribution, and chance to have micro-breaks during the working day. The point of view for interactions within a complex, socio-technical system can be seen in a way that considers the human role as the key element in interacting systems that comes to ergonomics and its load (Wilson, 2000).

Cognitive ergonomics also apply scientifically studied principles of human cognitive features; perception, attentiveness, memory, thinking, motor functions, decision-making, and areas related to performance (Haavisto, 2006). Also, human emotions and motivations are important. The cognitive requirements of working life, such as receiving information, applying the information, and generating information require cognitive processing from the employee (Meyer & Hünefeld, 2018). The cognitive requirements of work become negative when the requirements are combined with a high level of workload.

According to classical “The Yerkes-Dodson law” (Figure 1), the performance increases when raising the mental arousal optimally, but only up to a point (Gino, 2016). When the arousal, stress levels become too high the performance level starts to decrease. It will lead to an impaired performance because of rising anxiety.



**Figure 1: The Yerkes & Dodson law, 1908 from Gino (2016)**

#### 1.2.4 Other relevant terms and definitions

Additional relevant concepts regarding to the thesis work illustrated in the table below (Table 1). Understanding these concepts will help to follow the study in its circumstances.

Concept	Definition
Knowledge-work performance	For the performance of knowledge work measures can be carried out with four aspects: results, process, behavior, and physiology (Takala, Suwansaranyu, & Phusavat, 2006).
Knowledge-intensive organization	A company which success relies on highly qualified staff and the expertise of individuals (Jääskeläinen & Laihonon, 2013).

**Table 1: Other relevant concepts and definitions**

### 1.3 Research objectives and questions

Information and communication technology and the use of artificial intelligence have changed a lot in a short time and will continue to develop, which has provoked changes in all contexts and will continue to do so (Kalakoski 2019). For example, highly increased remote work (e.g., Charalampous, Grant, Tramontano & Michailidis, 2019) and rising amount of information from different platforms and digital environments (e.g., Roetzel, 2019) are factors that have changed working life in the past ten years. In work life, these changes can lead to job intensification and increase cognitive demands in work (Kalakoski, 2019), as well as increases cognitive strain which ultimately reduces the performance of knowledge workers.

This thesis is being executed to a case company, Huld Oy, which is a mid-sized consultancy company from Finland. The case company has some 450 employees that are mostly engineers with different backgrounds working on demanding development projects worldwide. This thesis focuses on the Product Design Center of Excellence in the company and is limited to mechanical designers and project managers. By means of this thesis, the case company is willing to

- understand the factors creating cognitive strain to the employees and how to reduce it and enhance the employee cognitive sustainability.
- understand the link between the cognitive work environment and its affection to the performance level in the case company.
- identify the tangible tools and techniques to be implemented in daily operations management and leadership.

Within this background, the objective of this research is

- to identify the potential factors that determine the level of performance.
- to define what is mean by good performance level in terms of knowledge workers.
- to gain an understanding of the factors that causes cognitive strain at work.
- to identify the ways that could help in mitigating cognitive strain and enable knowledge workers to perform well.

To fulfil the research objectives, the research questions were formed as below.

1. What are the factors that determine the level of knowledge worker performance and how to define a good performance level?
2. What causes cognitive strain at work and how to reduce the cognitive strain during the work-day in the knowledge work?
3. How the cognitive strain affects to the determined good performance level?

## **1.4 Limitations**

There are limitations in the theory background article search process. In the field of cognitive ergonomics, phenomena have been described with many different terms and concepts (Kalakoski, 2019). Reviewed articles in this paper have been searched with limited keywords. There might be relevant studies on cognitive ergonomics or related topics which do not use these keywords in their titles or abstracts.

Limitations for this paper also bring out the sensitive nature of the topic. Even though the interviews are being held anonymously, the interviews results shall be analyzed as one part of the research and not as an exact truth. Furthermore, the cognitive balance of an individual is usually a summa of factors from their private life and work life. In this research, we are focusing mainly on the work-life side and not researching extensively the private life of employees.

For the interview results a disclaimer that the interviewees in this paper are being in different kind of work-situation what comes to number of customers to work for, difficulty of the work tasks, maturity of the co-workers in the team, and other things that are not identified in this research. Due to that, the answers are not fully comparable to each other, rather giving a holistic understanding of what kind of possible challenges come to maintaining cognitive load in chosen knowledge work roles. However, the study group represents two different roles which are Mechanical Designer and Project Manager.

Also, what comes to analyzing the performance of an employees', there are no clear definition of good performance – level, or underperforming in the case company, neither are in the current research, what have been used as a theoretical background for this thesis. As Takala et al. (2006) defines in their study, the outcome of performance evaluation depends on three factors, 1. what to measure, 2. how to measure, 3. cultural issues.

## 1.5 Structure of the thesis

The structure of the thesis (Figure 2.) follows the general model of thesis works, the formation of research objectives and questions, which will lead to a theory background about the chosen topics. After that, there are interview study methods, the qualitative interview results and preliminary comments and analysis. Eventually, the key findings will lead the reader to the discussions and conclusions of the research paper with tangible suggestions for actions to be taken for the company based on the study as well as suggestions for future research.



**Figure 2: Thesis structure**

## 2 Background of the case company

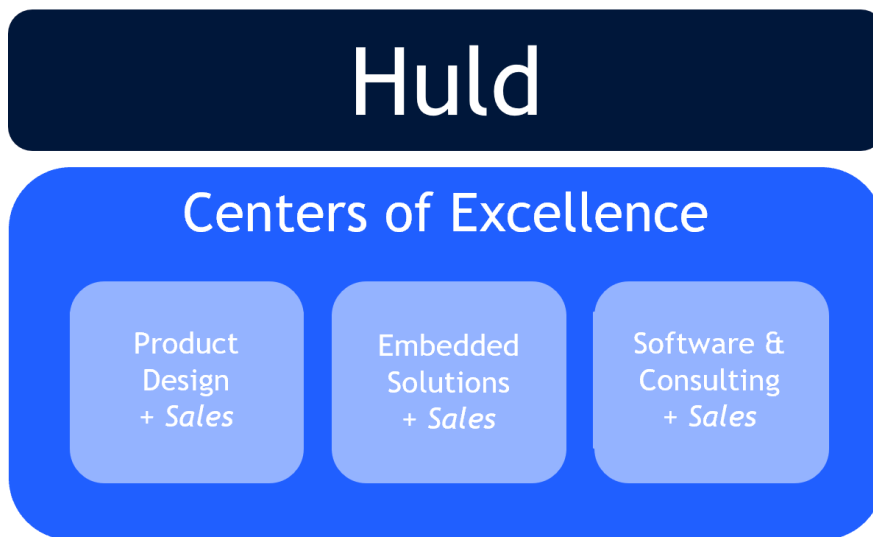
The thesis is executed for Huld, a Finnish technology company with approximately 450 employees, which responds to society's challenges by creating intelligent technological solutions. Huld serves its more than three hundred active customers with expert services in various areas of product and software development. The name Huld comes from the words humane and bold, which reflect Huld's values and way of working. The history of the company dates back more than 15 years, when the focus was mainly on the development of physical machines and equipment. Over the years, the company has grown both organically and through acquisitions, and with these, the knowledge capital has expanded into new areas.

Geographically, Huld's offices have historically been located close to key customers, but over the past two years, freedom of location has been strongly implemented in the operations. Whenever possible, customers are served regardless of the locality, and projects are carried out by remote teams. Huld's largest unit is in Espoo, which is also the company's headquarters. In addition, there are premises in more than 10 cities across Finland and in two cities in the Czech Republic.

Huld's customer base consists of companies operating in a wide range of industries, such as those in the mining, metal, forestry, space, pharmaceutical and electrical engineering industries, as well as in the public administration and security sectors. Actors from several different sectors set different goals for Huld's operations, but the same laws and competence needs are repeated regardless of the industry or sector.

To serve its customers efficiently and enable employee competence development, Huld has renewed itself for 2023 into an enhanced organizational model in which the organization is divided into three different competence units (Figure 3.), covering everything from sales to running daily operations and customer projects, as well as competence development. Each center of excellence is divided into its own teams, of which there are about 30. Additionally, the company has a company level management team, and business management team, related to the centers of excellence. There are also crucially important support functions, covering IT, quality management, corporate security, finance, people & culture, communications, and marketing.





**Figure 3: Company high-level organization structure**

Expertise, its efficient use, nurturing, and development are at the core of Huld's business. It is by far the most important capital of the company since there are no own products for sale. Each customer expects to receive professional and competent service when it suits their development project. Customers are willing to pay only for the benefit they feel they get, and the competitive situation in the market determines the appropriate price level for the services. Thus, a prerequisite for making a profit is the high invoicing rate of a wide range of knowledge workers, as the personnel account for more than 80% of the company's expenses. Creating a profitable business requires seamless cooperation between different parts of the organization, and at the heart of everything is the know-how sold to customers.

### **3 Theoretical background**

#### **3.1 Performance in the knowledge work**

The overall success of companies offering consultancy services and expertise is leaning on the individual knowledge workers and their performance level (Kalakoski et al., 2020). The knowledge workers performance is the key driver for the knowledge-intensive organizations; therefore, the improvement of knowledge work performance is the most important challenge for the knowledge-intensive organizations to solve (Groen, van de Belt, & Wilderom, 2012). Due to that, performance measurement has been studied topic in various fields of industries including psychology, human resource management, economics, accounting, and industrial engineering (Takala et al., 2006).

Currently there are no universally accepted methods for individual knowledge worker performance measurement (Palvalin et al., 2015). Knowledge work performance is a phenomenon that is seen to be difficult to approach due to its immaterial, qualitative, and changing nature.

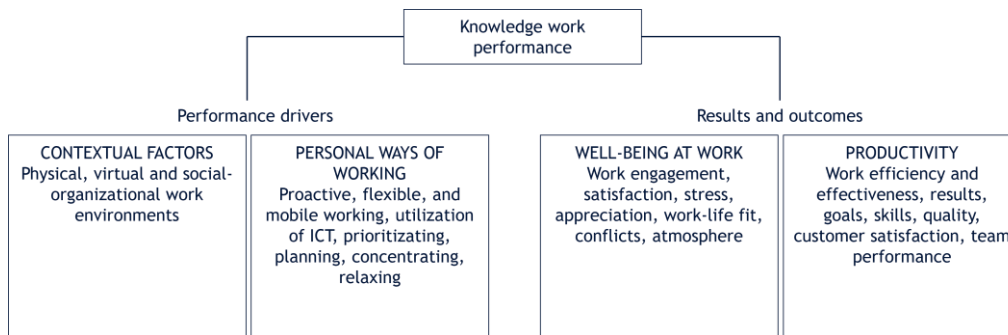
Productivity is seen as one part of the performance, as a tangible output (Ramirez & Nembhard, 2004). Productivity can be defined with following criteria; quantity, economic factors, timeliness, autonomy, quality, innovation/ creativity, customer satisfaction, project success, efficiency, effectiveness, responsibility/ importance of work, knowledge worker's perception of productivity, and absenteeism. However, even from the productivity point of view, very rarely are all these criteria considered when the knowledge worker's productivity is measured.

On the other hand, performance can be measured with a more holistically structured framework. For the performance of knowledge work measures should be carried out with four aspects: results, process, behavior, and physiology (Takala et al., 2006). In their study they have indicated various arguments that support the more holistic perspective for knowledge work performance measurement. For example, knowledge work is usually non-repetitive, output of knowledge work is usually impacted by number of external factors, output of knowledge work is difficult to quantify, decisions involved in the task are mainly semi-structured or unstructured. Additionally, it is rare for knowledge workers to function best alone, in fact, most knowledge workers perform

best in a collaboration with others. In general, both outputs and inputs are mainly intangible and complex in knowledge work.

In addition to these knowledge performance measurement methods Jääskeläinen and Laihonen (2013) propose a two-sided measurement method. In their study they recognized two specific aspects that should be considered in the performance measurement of the knowledge workers: the performance of knowledge workers and customer-perceived performance. For performance measurement of knowledge workers, they propose a subjective measurement of knowledge worker performance, which can include self-review and peer reviews additionally to superior review. Multiple evaluators are seen as an option to get more measurement accuracy. As the other measured aspect in parallel, customer-target-oriented measurement is as important action. It is a pragmatic way to the performance measurement of consultancy services, with not limited to customer satisfaction, but with certain measurement criteria of service outcomes. This helps to avoid the typical issue related to the measurement of performance. The internal efficiency of knowledge worker and the effectiveness of the outcomes from the customer perspective are combined.

Palvalin et al. (2015) have created a survey method for performance measurement in the knowledge work, their tool consists of two segments: performance drivers and results and outcomes (Figure 4.). Performance drivers consists of contextual factors, such as working environment and organizational context, and personal ways of working, which can be for instance individual work practices, ways to have control over schedule, workload and interruptions and ability to concentrate and relax. The well-functioning performance drivers are enabling the results and outcomes, other segment of the knowledge work performance. Results and outcomes consist of well-being at work, which can be for example work engagement, work-life fit, and satisfaction, and productivity, which consist of work efficiency, effectiveness, results, goals, customer satisfaction, quality, and team performance.



**Figure 4: Knowledge work performance definition according to Palvalin et al. (2015)**

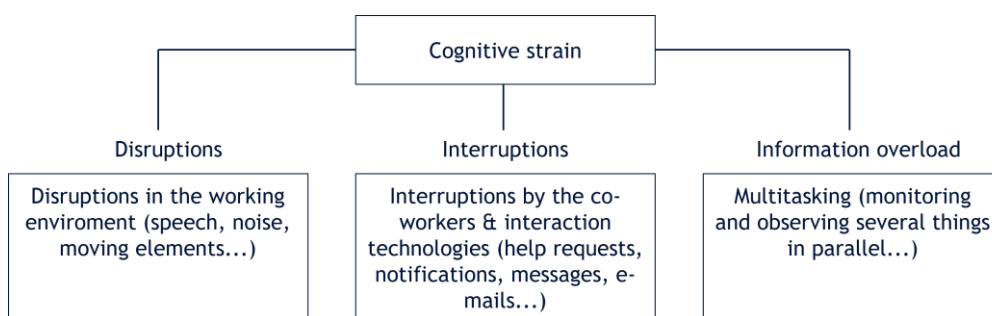
All these concepts of performance definition and measurement can be used individually for the performance evaluation but combining them to a one concept could have the best results in understanding the knowledge worker performance with its complex characteristics and measuring it multidimensionally, would give more accuracy.

### 3.2 Cognitive strain in the knowledge work

In the modern working life, the performance of work tasks is strongly leaning on the individuals cognitive functioning, especially in the knowledge work (Kalakoski et al., 2020). More specifically, the mental processes are involved in information processing, such as attention, working memory, decision-making, and learning. Knowledge work requires working with abstract knowledge and acquiring, creating, and applying knowledge, as well as continuous on-the-job learning.

Based on brain research, cognitive strain is a serious risk today, which is leading to a concentration problem of individuals (Huotilainen & Moisala, 2018). A long-lasting cognitive strain can create a chronic concentration decrease, and individual becomes to create own interruptions, even if there would be possibility to focus on certain tasks and duties. Decreased concentration ability can reduce the individual's cognitive strength, performance level, recovery from the work and ability to accomplish planned tasks and duties.

When the cognitive strain is managed well and concentration ability is good, it will affect positively on memory, creativity, social skills, and ability to manage the large and complex entities. Kalakoski et al. (2020) have identified in their study three main sources of cognitive strain: disruptions, interruptions, and information overload (Figure 5.). The disruptions can be for example speech, noise, or moving elements in the working environment, the interruptions can be co-workers interrupting the work, or interaction tools that interrupt the work, information overload then can be caused also by large number of information, monitoring several things in parallel and multitasking.



**Figure 5: Cognitive strain concept definition based on Kalakoski et al. (2020)**

### **3.2.1 Disruptions**

Office noise, background speech, and employees moving around in the open-office premises are seen typical reasons for disruptions and are experienced to be significant issues for knowledge workers (Jahncke, Hygge, Halin, Green, & Dimberg, 2011). In their study they found out that noise disruption caused cognitive strain which led to decreased working memory capacity and feeling of tiredness and decreased work motivation. Also, open-plan office noise effects cognitive performance and restoration. Bridger & Brasher (2011) found out that at the open-office premises disruptions caused frustration and self-control demand. Kalakoski et al. (2020) identified that disruptions in the work environment affect the employee ability to master cognitively demanding tasks.

### **3.2.2 Interruptions**

Main sources of interruptions are messenger messages, emails, phone-calls, and colleague interaction (Sykes, 2011). Sykes found that in the research group, as much as 71 percent of the workdays are spent solving ad-hoc interruptions. Especially, helping colleagues with issues was very time-consuming. It is also identified by Couffe and Michael (2017) that interruptions are a stoppage of an activity caused by, for example, people asking for help in an open-office setting. Also, Baether and Rigotti (2013) have found that interruptions cause unfinished tasks which led to time-pressure and cognitive strain. These caused irritation and dissatisfaction with employees' own work performance. Also, Kalakoski et al. (2020) identified that interruptions have harmful consequences for task performance, additionally to that, interruptions in the working environment have identified to predict a higher level of attention failures, which harms the workflow and due to that may affect negatively to productivity and a well-being of an employee.

Interruptions compared to planned micro-breaks do not reduce the stress levels or comfort the employee, on the contrary, it raises the stress levels and can cause irritation and anxiety (Repo, Ravantti, & Pääkkönen, 2015). Also, interruptions can be other organization related factor, such as employees' need for waiting a decision or information that will cause a delay for task completion, or then technical problems that prevents the employee from completing the tasks. Kalakoski et al. (2020) also found out in their study that interruptions lead the employees to switch from one set of tasks to another before finishing the first set of tasks which can lead to confusion in task management and inefficiency in task completion.

### **3.2.3 Information overload**

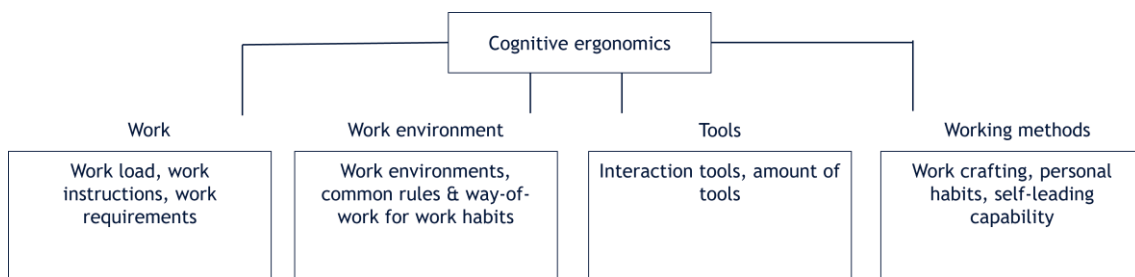
Sørensen and Holman (2014) have found out in their study that the most common concerns, a source of cognitive strain, are related to the task's ambiguity, uncertainty, and interdependency that can be called information overload. The complexity associated with administering, planning, and coordinating and the lack of information when a problem solution was acceptable. Kalakoski et al. (2020) also identified that information overload can be caused by multitasking, and new interaction technologies with constantly appearing notifications can hinder task performance. In more detail the information overload is seen to be caused by constantly switching attention from one thing to another, using several different devices, monitoring several things, and observing changes, working according to contradictory instructions, having too many messages to handle, not knowing whom instructions concern, and not understanding instructions.

Sykes (2011) found that information overload caused by multitasking makes work performance less efficient, due to it being resource intense and complicated. Switching the task completion back and forth is mentally very demanding and can lead to additional stress and lead employees to likely make errors. Also, Couffe and Michael (2017) identified that switching from task to another task affects a disengagement of attention for the primary task and can generate an interference with the ongoing goals that should be maintained.

### 3.3 Cognitive ergonomics in the knowledge work

Employees and in general human beings usually need mental load and challenges to remain healthy (Riikonen, Tuomi, Vanhala & Seitsamo, 2003). Working is usually the primary source for cognitive load, these can be for example factors related to the working conditions, working tasks, work arrangements, and interaction that are affecting the employee. The cognitive load related to the work can be a driver or a strain; the optimal amount of load can enhance engagement and enthusiasm, but on the other hand, the overload can have serious negative impacts on the overall well-being of the employee. Cognitive strain can for example raise the level of anxiety and mental illness.

In cognitive ergonomics the work is designed considering the human mental capabilities such as ability to process information (Kalakoski, 2018). Cognitive ergonomics considers the internal and external factors of employees', harmonizing the work itself, work environment, work tools and working methods in a cognitively manageable entity for the employee (Muistiliitto, 2023). The tangible factors under the divided concepts can be for example, in the work, the workload, or work requirements, in the working environment the common rules and work habits in the work environment, in the tools, the number of tools, in the working methods the personal habits and self-leading capabilities (Figure 6.).



**Figure 6: Cognitive ergonomics factors figure based on Muistiliitto (2023)**



Well maintained cognitive ergonomics at the workplaces are not only in the individual employee's responsibility, but rather involving the whole work community to define the common rules and way-of-work together invited by the organization (Kalakoski, 2018). Involving and engaging the working community to create common rules for the workplace creates better chances for the successful transition towards cognitively sustainable workplace. Additionally, in common discussion related to cognitive ergonomics, organizations can identify the situations where to focus to minimize the risk of distractions, interruptions, and information overload. Sørensen and Holman (2014) also pointed out in their research that improving the level of management and colleague feedback, and to formalizing rules and way-of-work for regulating task coordination and social interaction can have positive effects on knowledge work job characteristics and well-being.

Together, company-wise defined way-of-work can lead to the best success in maintaining the cognitive ergonomics (Kalakoski, 2018). Practically, there can be company level silent hours in the calendar when it is mandatory to give the colleagues a possibility to focus on important tasks. Interruptions can be reduced by defining that in lower priority questions there must be collected few questions before interrupting the colleague and asking for help. Additionally, in customer cooperation, can be defined a certain person, who is the primary contact-person for the questions and clarifications so that the whole team will not be interrupted. Also, defining the rules for the different levels of communication, which tools to use for which kind of communication and what will be the expected response-time in different interaction tools. Also, Sykes (2011) proposes that managing the interruptions can be handled with company-wise common email rules, for instance clear email messages and instant messaging only if necessary. Checking emails only in certain time slots and turning off notifications. Jahncke et al (2011) also highlights the importance of having common office etiquette and micro-breaks during the day.

Working environments include physical location, and virtual and social workplaces (Palvalin et al, 2015). The physical workplace should support the employees to complete the tasks, whether it requires concentration or collaboration with the colleagues to stay productive and creative. For example, there should be enough spaces for official and informal meetings, as well as spaces that can be used for concentration and orientation. Bridger and Brasher (2011) also underlines the role of privacy on cognitively demanding tasks, in their studies privacy is found to increase productivity and creativity. The open office environment is seen as a challenging work

environment (Sykes, 2011). A clear layout planning, quiet working areas separate from traffic premises, and common rules for the interaction in the office premises has been seen as helpful sustaining the cognitive ergonomics. Additionally, technology has an important role in providing employees with control, how to conduct their work, where to conduct it and when to conduct it (Vartiainen & Hyrkkänen, 2010). Well-functioning tools have crucial importance for remote-working employees for accessing information, and for efficient communication and collaboration. Tools can also help employees to increase their awareness and create a sense of belonging in a community which is very important for remote workers and virtual teams.

Individually, sustaining cognitive ergonomics is important during a working day and recovering from the work environment disruptions, for example noise, can be enhanced by stepping aside from the disrupting environment and listening and watching calming content (Jahncke et al., 2011). Also, individual work practices and behaviors are important to be supported (Palvalin et al., 2015). Whether it means that worker prefers to work at the office during the office hours or work flexibly at home. Employees can have control over the timing of their work, and the location where they work. Planning behavior, goal setting, prioritizing, and preparation for meetings help employees to focus on results and control their time and workload. Individuals can also manage interruptions for working remotely, when in need of concentrating or change e-mail and other interaction tool settings to avoid interruptions during the times when in need of focus.

## 4 Methodology

This chapter presents the design of this research. The chapter consists of information about the research philosophy, research approach and strategy, research method, data collection and sample, data analysis, and trustworthiness of the study. The following chapters contain justification and explanation for chosen tools and techniques, as well as discussions about the reliability and validity of the study.

### 4.1 Research philosophy

Research philosophy is to be outlined for research, to have convincing research, but also to create a justification for the methodological choice (Saunders & Bristow, 2023). The term research philosophy refers to a system of beliefs and assumptions about the development of knowledge. The research philosophy sets out the point of view for the research, impacting which data are prioritized and how it will be interpreted. In more detail, it is a belief about the ways how data should be collected, analyzed, and used about a certain phenomenon.

There are five different research philosophies in business and management research: positivism, critical realism, interpretivism, postmodernism, and pragmatism (Saunders & Bristow, 2023). Positivism focusses on strictly scientifically empiricist ways of work and is aiming to generate unambiguous and accurate knowledge via fact-based data, without facts that may have been biased by human interpretations. Critical realism focuses on explaining what we see and experience, regarding underlying structures of reality that shape the observable events. In critical realism reality is seen as an external or independent phenomenon, not directly accessible through observations or knowledge of it. Interpretivism then underlines that humans are to be differentiated from physical phenomena, based on the point of view that humans create meanings, which are studied in interpretivism study method. The purpose of interpretivism research is to create new, richer understandings and interpretations of the social world and contexts. Postmodernism highlights the role of language and relations, aiming to question accepted ways of thinking and giving a voice to alternative, marginalized points of views. Pragmatism is based on a view that concepts are only relevant, where they support action. Knowledge is valued for enabling actions to be carried out successfully.

Interpretivism in more detail considers the people different cultural backgrounds, different circumstances, and that at different times make different meanings (Saunders & Bristow, 2023). Interpretivism does not aim to create generalizations from the research data, but rather to create new, richer understanding, and interpretations of social environments and contexts. For business and management researchers, it usually means looking at the organizations from different perspectives of people groups inside the organization. Social complexity is to be noticed and collected research data should be meaningful for the research participants.

Interpretivism research philosophy is chosen for this study due to its fit for the research topic and research setting. Interviewees experiences and point of views for the cognitive strain, how it affects to the working performance and how to manage cognitive ergonomics helps to create understanding from the collected data. Also, in this study the empirical data will be gathered via qualitative research method, with a small number of interviewees.

## 4.2 Research approach

When the most suitable research philosophy is chosen, the research approach is presented. There are three different research approach methodologies that researcher can choose: deductive, inductive, and abductive (Saunders & Bristow, 2023). A deductive approach is an approach, where research starts with theory, and the research will then test the hypothesis, generated in the theory part in the actual research phase. The inductive approach starts with collecting the data to explore a phenomenon and after that begins the theory building also based on the observations in the data collection phase. Abductive approach then is a mixed method based on deductive and inductive methods, the theory part can be generated or modified based on the collected research-data. Abductive approach moves in between theory and data, making comparisons and interpretations.

A deductive approach is chosen for this study. The research started with building the theory background, which also worked as a base for formation of the interview plan, interview group, interview method, and interview questions. The interview results then are compared with the theory background.

### 4.3 Research method

The research method for this study is qualitative research. Qualitative research differs from quantitative research by not aiming to create statistical generalization (Alasuutari, 2011). Qualitative research is rather aiming to describe a phenomenon or event, or to understand certain activity or operation, or building and theoretical interpretation for certain phenomena. Qualitative and quantitative study methods are generally seen as opposite methods to each other. However, both methods can be used for the same research, so they do not close out each other. Generally, qualitative study material is rich, multilayered, and complex.

The qualitative research method is chosen for this study due to the aim to research, explain, and explore the cognitive strain, cognitive ergonomics, and performance of knowledge workers. In more detail, what kind of cognitive strain sources are for the chosen interviewee group participants, what kind of routines there are to maintain the cognitive ergonomics, and how does the cognitive strain and cognitive ergonomics affect to the performance of knowledge workers. To get a comprehensive understanding of such sensitive topics requires a qualitative research methodology, such as interviewees experiences, perceptions, and behaviors. The qualitative method provides deeper information on individuals than the quantitative method.

#### 4.4 Data collection and sample

The data collection process is divided into two phases. Firstly, to understand the case company context in the knowledge work performance definition, measurement, and management. The first interviews were conducted with the case company personnel, one interview for two interviewees working in a managerial role. After the first interviews, which results were used as an input for forming the second, the key interviews were held. The second interview was conducted with the case company personnel, working in two different knowledge work roles, Mechanical Designers and Project managers. In total for six employees.

The interviews followed semi-structured method and was one-to-one with each interviewee, interviews were conducted in Finnish, and were translated to English due to the thesis work requirements. The interviews were conducted via Microsoft Teams and were recorded, due to the sensitive nature of the topic, the interview results conducted anonymously to secure the interviewees personality. Interview recording gave the researcher the possibility to further remember, analyze and transcribe the collected data afterward. In the interviews, there were defined themes, detailed questions under the themes and follow-up questions were asked after brief or unclear answers. Additionally, interviews were designed in a way that there was ability to discuss and talk about things off-the-agenda, which were felt important of the interviewees to discuss. The interviews for managerial roles were 39 minutes, and 42 minutes in length, and for the knowledge workers from 33 minutes to 1 hour and 18 minutes in length.

In this research the data will be the interview transcriptions, that are in text format. The transcriptions were executed with Microsoft Word transcribing software, and the texts were double-checked for typo fixings and to avoid other software-based mistakes.

## 4.5 Data analysis

The data analysis method chosen for this research is content analysis. Content analysis is widely used in different research settings, and its purpose is to develop a representative description of text or other unstructured information (Lazar, Feng, & Hochheiser, 2017). Content analysis is systematic, replicable technique for compressing multiple words from the text content into a fewer content or theme categories. Content analysis typically aims to have in-depth analysis for theoretical interpretations that may create new knowledge.

The content analysis will be suitable for this study, which will enable to find out the common themes from the different interviews, even the wording would be varying in between the respondents. The data set is clearly defined, and context is understood in this study and the interviews follow the same interview plan, which will help to generate the common themes and coding for the content analysis. That way the bias can be minimized what comes to the content.



## 4.6 Trustworthiness of the study

Qualitative research, and in this case, the sample size what comes to the number of respondents, is rather small. This research cannot give a holistic understanding of the status quo of the case company but gives a deeper understanding of the respondent's point of view. However, the results and analysis can indeed reflect a bigger population, but based on this research the generalizations of this study results are not recommended, even if possible. Generalization requires a study defined according to quantitative study method. What comes to the overall results of the interviews, the answers could have been different if there had been a bigger respondent population engaged. A notable thing in this respondent group was that all the respondents were very happy about the possibility of working remotely from the home office, which they were also doing quite a remarkable part of their working time. This was interesting, but most probably does not represent the whole personnel point of view. Also, all the knowledge worker respondents were Finnish citizens and male in gender.

The transcriptions from the interview recordings were executed with Microsoft Word transcription software, even though the data was double-checked to avoid typos and mistakes, that is to be considered as a risk for bias. Also, the interviews were conducted in Finnish and were translated to English for this thesis. That may have had an impact on the authenticity of the content. However, the translation has been done with the best possible accuracy to mitigate this risk. The case company have both, the Finnish and English versions of the transcriptions.

The interviewees were informed about the research framework, and they had a possibility to educate themselves about the cognitive strain sources, cognitive ergonomics, and knowledge work performance. However, these themes were not well-known by the respondents, especially cognitive strain, and cognitive ergonomics themes. The respondents were well prepared, but some confusion occurred with the concepts of cognitive strain sources and how they differ from each other, e.g., disruptions and interruptions.

It is also possible that with different research configuration, changing the respondents, interview setup and questions, the study results could have been different. Qualitative research enables more risk for bias generated by the researcher, even if there would be true will to be objective when building the research setting and throughout the research process.

Lastly, a notable thing will be that all the respondents were willing to be part of the interviews. For the interviews, it was positive, but also something that must be considered as one factor that may have an impact on the authenticity of the interview results. Sometimes the most needed, and insightful answers can be found from the respondents, who are not willing to share their opinions at all.

## 5 Results and Analysis

This chapter presents the findings of the interviews. In the study, there was conducted two sets of interviews, firstly with the company managerial personnel, for two respondents, to understand the status quo related to the knowledge worker performance definition, measurement, and leadership. The second interview set focus was to build understanding of the two different kinds of knowledge workers roles, responsibilities, and daily working routines, which in this study were Mechanical Designer, and Project Manager roles. On top of that, the focus was to gain information about the defined cognitive strain sources; interruptions, disruptions, and information overload and how do they affect the knowledge worker's cognitive balance. Additionally, the knowledge workers individual routines to sustain the cognitive ergonomics and how do the knowledge workers feel the cognitive strain may affect their performance level, were mapped out in the interviews. The results of interview answers are introduced according to the themes of the theoretical background. The chapter ends with a theme map which summarizes the key findings of the interview results.

## 5.1 Work performance in the case company point of view

To understand the work performance in this study's circumstances, the preliminary interviews were conducted for two case company representatives, working in a managerial role. The goal for the interviews was to understand the case company's definition for work performance, performance measurement, and performance management. In the table below is presented the respondents role in the organization, years of experience in a role, and years of experience in a company (Table 2.).

Respondent	Role	Years of experience in a role	Years of experience in a company
1	Upper Management	5	7
2	Team Leader	4	6

**Table 2: Interview respondents from the management**

### 5.1.1 Performance definition

In the interview results, we can see that the work performance is mainly seen through the productivity factors, and, that there are no common, standardized definition for good performance level in the company, thus there are not standardized measurement methods for that.

*"There have been discussions about how we know that [the employee] has performed well, what is the level of competence and defining it in such a way that it would be generically defined by Huld, where there are really many different competences - it's just impossible. The understanding of how to define what is good, excellent or bad performance should be there within the competence area, somehow." (Respondent 1)*

*"If we are talking purely about the definition, then it is not, at least in my opinion, comprehensive, how it is defined at our company. So, it is a bit situation-specific and very common knowledge and intuition based. I do not know whether there are still clear goals regarding what a person should fulfill for them having performed well. ... As such, it is a bit, perhaps even emotionally based, when judging whether someone has performed well and done well. ... If one were to think unequivocally about the answer to that question, the situation would require a sufficient level of performance of the tasks assigned." (Respondent 2)*

The definition for the employee performance is not clear for the company, and the work usually happens outside of the team leader's direct supervision. That makes it even more difficult for the leaders to know how the employees are performing in their daily work.

### **5.1.2 Performance measurement**

In the company, there are no defined methods for performance measurement. The measurement is primarily leaning on customer feedback, and in some cases, colleague feedback.

*"Customer satisfaction is certainly the most important [measurement indicator], because if we do not have customers, we do not have work for our employees, but without employees there are no customers, so it's an egg-and-chicken phenomenon. But perhaps in this context of performance, - by default the customer feedback is probably at this point [performance indicator]." (Respondent 1)*

*"We have no actual indicators, other than the customer feedback. That is, if customers give good feedback, it serves as the only indicator, but perhaps not the most effective indicator because not everyone gets feedback, even if they do their job extremely well. ... We are indeed then at the mercy of the customer's feedback, e.g., what the customer has thought about the quality of the work and performance. ... Well, schedules of course and staying on schedule and the fact that if the schedule has not been stayed in, then what has been the actual root cause of it." (Respondent 2)*

As can be seen from these answers, customer feedback plays a critical role in the performance measurement in the company, however, not customer feedback is always available. Additionally, in the interview there was a question about how the respondents would describe the maturity of the performance measurement in the company now.

*"If you think specifically about the performance measurement, it would certainly be good to develop some monitoring and some tools to make it visible that now-it's probably more of a "gut-feeling" coming from the team. ... I would say that we are in very early stages regarding that ... I have not seen any kind of "umbrella" that would cover the whole company [level performance measurement], at least not myself." (Respondent 1)*

*"It could certainly be better, and I myself at least appreciate a type of systematic environment and types of monitoring. Now we have these Huld Talks where discussions are held, but we do not have a very clear systematic definition, so it could be improved." (Respondent 2)*

To conclude, the managerial role respondents see that there is a point of development in the performance definition, but also, performance measurement.

### **5.1.3 Performance management**

As mentioned in the theoretical background, the knowledge worker performance is the key driver for the knowledge intensive organizations, therefore, the improvement of knowledge work performance is the most important challenge for the organizations (Groen et al., 2012). In the company, performance management, and its various aspects, are seen very important, and there is a willingness to support the employees and their ability to perform well.

*"Huld Leaders have been trained. ... Coaching leadership and an early support model as principles. ... Freedom of location - if the client does not require you to be physically in a particular place, then you can work where you are comfortable. We also have a "Train the Brain" - budget, so that people can train and develop their own skills, as far as this is of course possible alongside and within the framework of their work. I wouldn't either underestimate the importance of collegial support, because it certainly plays a very big*

*role, and is certainly under the radar, so to speak, and we don't even know how big a role it plays." (Respondent 1)*

*"I would say that occupational health as one of the factors, at our company it is very comprehensive. ... Salaries, of course, that we try to keep equal. ... We should be able to arrange a peaceful working environment for everyone and, in principle, we cannot influence how a person works at home, but we should arrange such conditions in the office that they [employees] can work in peace even though there are other people around. ... Motivation can also include stimulating events of this kind and after-work things, all kinds of activities that improve community spirit and can generally make a person feel better. And the old truth that a happy employee is an effective employee is absolutely true." (Respondent 2)*

In the company, there are many support functions for the employees, and it is seen that the employee well-being and performance goes hand in hand. Focusing on the employee's well-being is seen to be beneficial also for the ability to perform well in the work. Furthermore, good performance and success in the work are being rewarded to enhance the positive atmosphere.

*"We have these everyday awards, we have these Huld Hero and Superhero awards and there are also specific criteria that justifies the award. And yes, the fact that a customer gives good feedback, or a colleague gives you good feedback justifies it [the award]. That's how it starts, and then of course it's important that the good work is made visible and that there are reasons why and what has been done. ... The awards are gift cards of one hundred and two hundred euros that a person receives, and nowadays you can choose whether to take it as money or as a gift from Mastermark. ... Then they will be celebrated at the latest in the center-info or in the public info, then we will go through who has been awarded and for what and applaud and thank them." (Respondent 1)*

*"We try to reward and encourage the type of performance, where things are going well, our reward system in itself is quite comprehensive and there are also tiered steps in terms of what you have done. In addition, the Huld Leader should at least go through all the good feedback, as well as bad feedback, with the person whom it concerns and discuss it a bit." (Respondent 2)*

#### 5.1.4 Managerial challenge to performance evaluation, follow-up, and management

The nature of the business in a case company is based on the consultative work for the customers, that way, it means that the direct supervision is sometimes a bit far from the leader's daily routines. It creates a challenge for performance evaluation, follow-up, and management.

*"It [the job] also emphasizes the responsibility of the individual, that then one should boldly state that "hey, my skills are not enough for this, I don't know how to do this."  
(Respondent 1)*

*"The worst possible situation is that we have someone who works directly to customers as a single resource and there is no one else doing so, basically I can just watch it from the side, what they do and I get some kind of understanding, but then the actual product - I usually do not understand much of anything or what the customer does, so in that sense it is a very holistic review, so it is very challenging. ... Yes, so I feel inevitably distant [to the employee]." (Respondent 2)*

To conclude the whole chapter, there can be seen a chain of challenges for knowledge work performance definition, follow-up, and management. In worst case scenario, the leader might not know what the employee is doing, the performance definition is not clear, and measurement methods not defined nor in use.



## 5.2 Cognitive strain in the knowledge worker's point of view

Knowledge workers in this study represent two different roles, Mechanical Designer and Project Manager. The interview results are processed in this chapter. In the table is described the respondent's role, years of experience in a role, years of experience in a company, and typical number of projects with each respondent (Table 3.).

Respondent	Role	Years of experience in a role	Years of experience in a company	Number of projects
1	Mechanical Designer	2	1	1-2
2	Senior Mechanical Designer	12	6	1-2
3	Mechanical Design Specialist	20	2	3-5
4	Project Manager	7	3	5-6
5	Project Manager	8	2	2-3

**Table 3: Interview respondents**

### 5.2.1 Disruptions

Office noise, background speech, employees moving around the open-office premises are seen as a typical reason for the disruptions and can be significant issues for knowledge workers (Jahncke et al., 2011). It can also be identified from the interview results; all the interview respondents we're working with hybrid-model, partially from home-office and partially from office premises, and the home-office we're seen as a more natural choice to work. The challenges in the office premises are described as follows in the interviews.

*"At the office, if someone is having a meeting next to you, it can disturb your own concentration. Then helping colleagues, when they ask questions, so of course it always disturbs, but I like to help whenever I can." (Respondent 2)*

*"Sounds and movements and the noise they make are the problem, even though attempts have been made in the open office to reduce this with acoustic panels and so on, but at least in my case it doesn't affect me in any way, because if I'm sitting here and I can see over the computer, I will pay my attention to the people [noise and movements] while I'm working." (Respondent 1)*

All the respondents stated that the hybrid-model working arrangement is something that they will continue also in the future. The possibility of hybrid work was well appreciated by the respondents and is seen as a benefit for their work. It can be seen as a tangible way to manage the cognitive strain caused by disruptions, and due to that an enabler of individual employee's overall cognitive ergonomics and a well-being.

### 5.2.2 Interruptions

Sykes (2011) identifies that main sources of interruptions are messenger messages, emails, phone-calls, and colleague interactions. These were also mentioned in the interviews. The office environment was also mentioned, where interruptions mostly occurred. The respondents identified the interruptions as a source of cognitive strain and some of them had organically built their own routines to manage and limit the number of interruptions.

*"Calls for help from colleagues, or just some other thing that comes up or a message on your mobile phone. Anything that interrupts the work."*

*(Respondent 2)*

*"There are such interruptions all the time, e.g., we need some information that we are waiting for and will perhaps receive at some point." (Respondent 1)*

*"It feels that the notifications come to the point of annoyance, so that if at some point you think, OK, I'll just look at them now so I can work, and then again they [notifications] come pouring in. So that you can't get rid of them at all." (Respondent 5)*

*"Here [in the office], it may be the interruption of colleagues, so as, of course, I will also perhaps interrupt them [colleagues], especially if you are in the same project with a designer. Such interruptions occur in the office." (Respondent 5)*

Due to the interruptions, respondents felt that it is difficult to get back to the original task that they were performing before the interruption and that is causing problems with their task management and eventually, a wider problem with scheduling that will cause stress for the respondents.

*"Just when you're thinking or concentrating, if any kind of interruption comes into it, five minutes later you don't even remember what you were doing. You're wasting time for nothing, so it's important to minimize that." (Respondent 3)*

*"If the interruption breaks the concentration, then you have to find the common thread again and try to catch it." (Respondent 1)*

*"I feel that it takes more time when you go back to what you did before the interruption, to get back to what you were thinking about when you were working on the excel spreadsheet. ... Also, it seems as if this 10-minute work now takes half an hour when it's interrupted and because of that you've had to think about it way longer." (Respondent 5)*

Based on the interviews there is an unwritten rule of how to signal to colleagues not to interrupt with the Teams-application statuses and some respondents limited their interruptions with closing the interaction tools for certain periods of time or reserving a time slot from their own calendar which blocks it from others to disrupt them during that reservation.

*"I know that some people, because of the interruptions and the information overload, put [Microsoft] Teams on "do not disturb" mode. That way people might know that something important is going on." (Respondent 1)*

*"I then try to close those applications and try not to be available. If there is a certain thing that needs to be done at the right time, and you must focus on it, then you have no choice but to close the sources [of the notifications]. For example, when you close Teams completely, it makes it much easier." (Respondent 5)*

*"I try to manage my calendar and take the time to do the tasks, so I book meetings for myself as a calendar reservation, which blocks the calendar, so no one else can book something for me." (Respondent 4)*

To conclude, interruptions are experienced as a problematic for the work. Interruptions can be generated from various sources, and due to that it is more difficult to manage them, for example by changing your working location. Especially, in the tasks that require ability to focus, it might be that only working from home-office is not enough, but also closing the interaction tools, or reserving a timeslot from your calendar will help you to succeed in your task. That is also an organically developed routine for the respondents, how to limit the interruptions. Also, respondents understand the interruptions affect the schedule and costs, which may have a large impact on the company level, even if it would be a minor problem for individual employees.

*"As a suggestion, if someone would calculate how long it takes, after a distraction or interruption, to get back to what you were doing - it's a shocking amount of working time that is completely wasted. And usually they are very secondary things, like when a colleague comes and says, "well then, let's go for coffee", just when you were thinking about it [the solution]. And yes, it's very good to take a break and go and rest, but the downside is that when you come back to the computer you spend half an hour staring at the screen with glazed eyes trying to remember what was going on, like "I don't remember anything"."* (Respondent 3)

*"They should spend a little more time and thought on it on a general level, so that perhaps when the whole thing is studied, they could find quite surprising things, e.g. how big an impact the little things have all together [on a company level]."* (Respondent 3)

### 5.2.3 Information overload

The information overload caused by multitasking makes the work performance less efficient (Sykes, 2011). Switching the task completion back and forth is mentally very demanding and can lead to additional stress and to likely make errors. Information overload and multitasking has also been experienced within the respondents, and they are seen as a source of cognitive strain. However, multitasking can also be caused by the employee itself, for example, listening to a podcast or such during the work might cause the information overload. Also, multitasking can be a natural part of work tasks, if there are certain work packages that need to be progressed in parallel, so multitasking is not automatically a negative thing, but rather a nature of certain projects.

*"Of course, many times there are several interconnected entities that need to be worked at the same time, so that you can't finish one and then move on to the next, for example, depending on the schedule, you have to get parts or molds ordered and other things like that, so you have to bounce from one thing to another to further them simultaneously."*  
(Respondent 2)

*"The projects are all going on at the same time and they are at a certain stage and there is always something to do. It's very typical that one week one client is a bit quieter, but the other two clients are busy, so it fluctuates and wavers between the two. Now, indeed, quite manageable [workload], but a year ago it was not so nice, everyone wanted everything at the same time and then you had to work a longer day"* (Respondent 3)

*"I also cause it by listening to podcasts while I'm working, so I kind of focus on two things at the same time. Then the fact that there are two different projects at the same time, so I have to answer both messages and calls and come back again to see what it was about this other thing, then I had to finish looking at it when I had already looked at it in another project."* (Respondent 1)

Information overload, then, is caused by the interaction tools and in the phases when the cumulation of starting and ending projects creates too many projects at the same time can cause negative periods of information overload. As Kalakoski et al. (2020) defines, information overload can be caused by new interaction technologies, monitoring several things, and observing changes.

*"Well, it's a shocking amount of information. I also like to look for information by asking other people, so it doesn't feel so heavy - the information. So that I didn't have to look for it myself, something like standards and so on." (Respondent 1)*

*"The amount of information is clearly more of a challenge. Partly perhaps just because if you are in several different projects at the same time, then if there are now more projects where something happens, then the information usually is quite a lot, and then just filtering it, and the fact that you get to pick out the relevant things from the information stream." (Respondent 4)*

*"The flood of information is actually so huge or the channels through which we are expected to communicate are so many, there will be all kinds of interruptions. ... At least for me, all these kinds of notifications and other disturb me, because even now I am disrupted all the time when Teams show that there is a red ball and number one in it." (Respondent 5)*

As a conclusion, it can be clearly understood that the information overload is an issue for the employees. However, the information overload is not necessarily only because of the work but can be caused because of employee's own choices or behavior. Therefore, a clear understanding of the consequences of the information overload should be clear for the employees to enhance their self-leading capabilities.

#### 5.2.4 Affects of cognitive strain

The well managed cognitive strain positively affects concentration ability, memory, creativity, social skills, and ability to manage large and complex entities (Kalakoski et al., 2020). In the interviews, cognitive strain related to these factors was mentioned by the respondents and were seen problematic for the work performance and employee well-being. In the interview there was a question about how cognitive strain affects the employees.

*"It certainly occurs in such a way that some things you tend to forget and then remember later like, oh well, this should have been taken care of. Of course, it does have the effect that you are more tired after a day's work." (Respondent 2)*

*"Lack of concentration is the first thing that comes up, or if you can only concentrate for a short moment on something and then something keeps coming up, your work efficiency decreases. It's quite clear. You can't get things done and things are left unfinished and hanging. ... And then it starts to show a little bit in the rest of your life as well outside of working hours, you start to worry about the working schedules, because you haven't had time to do and complete the work." (Respondent 3)*

*When there is too much workload for a moment for various reasons, you can see it. You can see it in every matter, your brain goes into overdrive when you should be going to bed and you're still planning something in your head for an hour or you wake up earlier in the morning to do something because it's just running around in your head. ... If the workload is too much, it takes a long time to get rid of it. (Respondent 3)*

*"For me, it makes me bored and anxious, if you can call it that. Sometimes I just want to close the laptop and go off and do something else." (Respondent 1)*

*"Yes, after such [stressful] days the cognitive resources are sometimes quite empty. So, in my current job I sometimes worry, and maybe some work issues have affected my sleep more than before. " (Respondent 4)*



As a conclusion, can be said that the cognitive strain has negative impacts on the employee's overall well-being also outside of work.

### 5.2.5 Cognitive strain and work performance

In the interview, there was a question about how the employees see how cognitive strain affects their working performance.

*"Of course, it is that if you can concentrate on one thing at a time without interruptions, you're likely to get it done faster and better. ... [When there is a cognitive load] you don't get as much focus on something and you might miss some things in the design work, then you make mistakes that you have to correct afterwards. Things that should have been noticed, but there were other things to think about." (Respondent 2)*

*"Things are left unfinished and schedules are stretched for sure when the concentration is disturbed and then at worst you become careless. When concentration is disturbed, you start to forget and don't notice the essential things. ... When the load is too much, you don't come up with anything new. You're stuck with the same old stuff and you're doing the same old thing you've been doing for 30 years. ... If the load is too much, you don't come up with anything new and you completely lose the innovation side of things, which is again important in these jobs." (Respondent 3)*

*"It may also be my own limited experience, but I feel that my decision-making ability suffers, I don't really know whether I dare to make decisions and I don't really know whether I can do this, even though I have always known that I can do this." (Respondent 1)*

*"For example, the kind of proactive and forward-looking planning that we do is pretty much neglected. Time is spent only on putting out fires and then a certain part of the project manager's work is lost. ... Things can become more straightforward. ... The likelihood of human error also increases, and that shows up in your own work in the fact that you forget things or forget to take care of things." (Respondent 4)*

*"Yes, it [affects] the fact that I now have to do this quickly. You want to take the easy way out" (Respondent 5)*

As we can see, the cognitive strain, in practice, affects the employee's quality of work, when needed to prioritize the schedule, the quality of work can reduce. Also, the number of errors and mistakes will grow, and difficulties to make decisions. Moreover, the innovative work and capability to create something is difficult when experiencing cognitive strain.

### 5.3 The role of cognitive ergonomics in the knowledge work

In the modern working life, the performance of work tasks is strongly leaning on the individuals cognitive functioning, especially in the knowledge work (Kalakoski et al., 2020). More specifically, the mental processes are involved in information processing, such as attention, working memory, decision-making, and learning. Based on the interviews, these seem to be the relevant issue among the respondents. In the interview there was a question about how the employees see that the cognitive strain is affecting their working performance.

#### 5.3.1 Cognitive ergonomics & self-leading skills

Kalakoski (2018) has defined that the well-maintained cognitive ergonomics at the workplaces are not only in the individual employee's responsibility, but rather involving the whole work community to define the way-of-work together invited by the organization. However, in this chapter we are focusing on the individual employee's routines to maintain their cognitive ergonomics to gain a better understanding of the employee's behavior. It is also interesting to understand individual employees' self-built routines outside of the office environment, since all the respondents are working a minimum of half of their working time from the home office. The home office is seen as a better place to focus and be productive, and additionally to that, it gives flexibility to the off-work tasks and comforts the management of daily routines.

*"The type of work I have now is such that I would argue that it's much more efficient to do it at home. ... I do have a comparison here, so the distractions and interruptions and so on are almost zero [in a home office]. If I'm in an open office, it's quite clear that a couple of hours of that day will probably be wasted on everything else." (Respondent 3)*

*"In the home office, at least as a rule, it is calm to work, so that there are not so many disturbances and interruptions." (Respondent 2)*

*"Well, in my opinion, a certain kind of flexibility is better in a home office. Commuting does not take time - depending a little on the office, I would argue that the main thing at home is calmness, so there's more peace to do [work]. There's less [disruptive] hassle or other interruptions like that." (Respondent 4)*

*"The good side is that there is more working time [at the home office]. ... That you can get straight to work and use your time efficiently [working time]. That's one of the good things about the home office. And also, the fact that it is flexible in terms of personal matters." (Respondent 5)*

As it is seen, the disruptions and interruptions as a source of cognitive strain have been able to be tackled by the flexibility of working arrangements, moving the work from the office premises to the home office. Covid-19 can be assumed to play a key role in this transformation, which could have brought positive change regarding the disruption's avoidance for knowledge worker's job. The following question in the interview aimed to find out what kind of routines the respondents had for maintaining their cognitive ergonomics in general during their workday.

*"The main thing is that if I feel that there is a lot [of workload], I take a pen and paper and write down what I had to remember and do. It makes it easier for me when more things start piling up. For some reason it works for me to write on a post-it note. ... if you feel that time is simply not enough, then you bring it up and together we share the work and see what is most important and whether some of it can really be left for later." (Respondent 2)*

*"Let me give you an example about tomorrow. I'm supposed to help with a tender calculation for a project and we're not in a hurry yet. It should be ready in a couple of weeks, so I took 3 hours for myself in the calendar, and it's marked in the calendar as private, so that time shows up as booked in Teams. I book myself time in advance and it means a lot to me. Prioritization is sometimes difficult because all customers are kind of equally important. ... Also, sometimes if there are things that can be delegated, then my strong recommendation is that you should do it. You can also agree with your manager that someone else will do it. ... I now have a problem that quite a lot of these things are things that cannot be delegated, that's the downside." (Respondent 3)*

*"If I'm at home then I'll go for a 10-minute walk outside and that's probably what I like about working at home. Of course, you could go out in the office as well, but you never get out there. ... Lunch breaks split the day in the middle of it, that's a good thing. For a while you go away from work and then you come back, the so-called reset." (Respondent 1)*

*"Small breaks of course, ... and it's when you get to talk to someone about difficult situations, at least those. ... If you notice that there have been several meetings in a row, you should set aside some time in your calendar where you need to be empty so that you can break off [the meeting pipeline]." (Respondent 4)*

Additionally, in the interviews there were mentioned the self-leading capability as an important factor for individuals to maintain their cognitive ergonomics.

*"I deal with that issue in ways that very much emphasize self-direction and managing the situation yourself, how you can keep things moving forward. Especially if you feel that it would be difficult for someone else to help you more with the issue." (Respondent 2)*

*"It has quite a lot to do with managing your own work and time management in general." (Respondent 4)*

### 5.3.2 Organization role in the cognitive ergonomics

As defined in the previous chapter, the organization role in building the cognitively ergonomic working environment is highly important (Kalakoski, 2018), so in this chapter we are pointing out the respondents' viewpoints on the questions, that how they see their organization is helping them in reducing the cognitive strain, and if possible, what could the organization do better to minimize the cognitive strain for the respondent's daily work.

*"Usually, if you start to feel that you are running out of resources and other things, help is usually available, so in this respect, the support is quite good. ...If you tell the project manager that now there is a bit too much work in relation to the schedule and ask whether to extend the schedule or take more resources, that's the most practical way forward." (Respondent 2)*

*"Every month, we go through the workload we have with certain group of people. Do you need help and who could help? This is well organized in this company. ... Yes, they try to monitor [workload] and it's okay in that sense. ... It's also good that Covid-19 came along and made this remote working possible because it has probably changed the way many people do their work and I actually think that for quite a few people it [remote working] is surprisingly suitable in many ways." (Respondent 3)*

*"I do believe that there will always be some support for everything. ... The hybrid work that makes a lot of things possible." (Respondent 1)*

*"Yes, I feel that Huld provides all possible resources for the job. Remote working is, of course, one example of how Huld manages it very well." (Respondent 5)*

The leader's and colleagues' support are appreciated and seen important among the respondents; also, the possibility to work from the home office is clearly a very positive thing for all the respondents. For the points of development, the respondents identified the following things.

*"I can imagine that for a younger person, it can feel overwhelming when there are so many things to get done. Maybe there could be more support and you could ask more often how things are going and stuff like that. ... Of course, it's about having enough resources in the project, and not putting younger people to work alone. It's something you can't influence yourself, other than to say that it won't work, I cannot do this."*

*(Respondent 2)*

*"Of course, about the means of communication, perhaps related to the distribution of internal information and other things, so accuracy in whether all the information is absolutely necessary for your own work." (Respondent 5)*

*"It would make sense to be aware that it really depends on the work and the nature of the work, what percentage of invoicing or invoicing rate is reasonable to aim for. ... So as far as my own work is concerned, the supervisor does not know exactly what I do on a weekly or daily basis, and it is not possible. In the current organizational structure, the teams are quite large, and one Huld Leader can be responsible for so many people that when people have many projects and so on, they can't keep up with their tasks, and it's not intentional" (Respondent 4).*

*"In that sense, we're doing pretty well, that all the things in the world can be done better. On a more general level, let's take care now that the company is still growing, that the recruits and skills are then right there, so it helps everyone." (Respondent 3)*

*"In practice, the organization could support in the sense that if there is a tight spot, you can ask for more hands from somewhere. And yes, they might be asked now as well. The challenge perhaps comes from the fact that in many situations it is a bit difficult to get an extra pair of hands directly involved in the work. ... It takes double the time and effort versus doing it yourself, and it's usually quite difficult to get the extra hands involved." (Respondent 4)*

As a conclusion for the points of development, the leader's role is seen important and something that could be further developed, what comes to the support for younger employees. Also, information distribution and its amount are something that was stated by respondent. Additionally, regarding the colleague support and extra-resourcing, it was said that it is difficult to bring new resources to the projects and on the other hand, perhaps more qualified employees could help in this. Keeping the talent pool's seniority and competence at a good level can help for many work-related challenges.



## 5.4 Summary of key findings

This chapter concludes the knowledge worker interview results. A further summary of the findings is provided following the content analysis method, with the help of identified themes from the interview results. After that, there are answers for the research questions. Additionally, there are theoretical contributions and suggestions for future research presented.

<b>Theme</b>	<b>Number of occurrences</b>
<i>Project</i>	56
<i>Office</i>	40
<i>Interruption</i>	34
<i>Customer</i>	30
<i>Disruption</i>	23
<i>Remote work</i>	21
<i>Communication</i>	20
<i>Design work</i>	20
<i>Focus</i>	18
<i>Multitasking</i>	18
<i>Meeting</i>	15
<i>Information</i>	14
<i>Teams software</i>	14
<i>Information overload</i>	12

**Table 4: Identified themes from interviews.**

The table upon (Table 4.) presents the themes and their quantity from the interview results. The themes can contain more than one synonym related to the theme, for example, *Remote work* – theme contains words such as *home-office*, *remote work*, *home*. The themes have been identified by detailed analysis of interview content and collecting the most frequently occurring synonyms of words and collecting them under a certain theme relevant to the study.

### 5.4.1 Theme mapping

The themes *Project* and *Customer* were quite frequently occurring in the interviews since they are linked to every other theme in one way or another. The business nature is project-based business, and the services are design projects. They can be seen as high-level themes tying together the whole topic.

Theme *Disruption* occurred in the interviews 23 times, that theme was mentioned together with the *Office* (40), *Remote work* (21), *Design work* (20), and *Focus* (18) themes. Disruptions was quite a big topic, especially for the Mechanical Designer respondents, who underlined the importance of not being disturbed during their work. Design work requires an ability to focus on succeeding in the problem solving related to the various tasks of design work. Office environment was seen a problematic, especially open office space, for the design work. The sources of disruptions in the office premises according to the respondents were noise, moving elements, and colleagues asking for help.

The respondents felt that the transformation towards location free work and hybrid work was a great change, that the Covid-19 crisis enabled for their daily work. There was a clear signal that this will be the new normal, and there is no way back to full office work, if possible, to remain location free. Respondents felt the location free working possibility as a substantial bonus factor for their work. What was interesting, employees were talking a lot about the *disruptions* in the open office and the positive effects of the home office work for their ability to focus and perform well in their work, but they did not mention the *disruptions* the most challenging source of cognitive strain for themselves. That can be indeed, because now they are able to manage the *disruptions* by staying certain days at the home office and allowing themselves to have the focus days for their important work tasks to be done. *Disruptions* were experienced as the least source of cognitive strain among the *disruptions*, *interruptions*, and *information overload*.

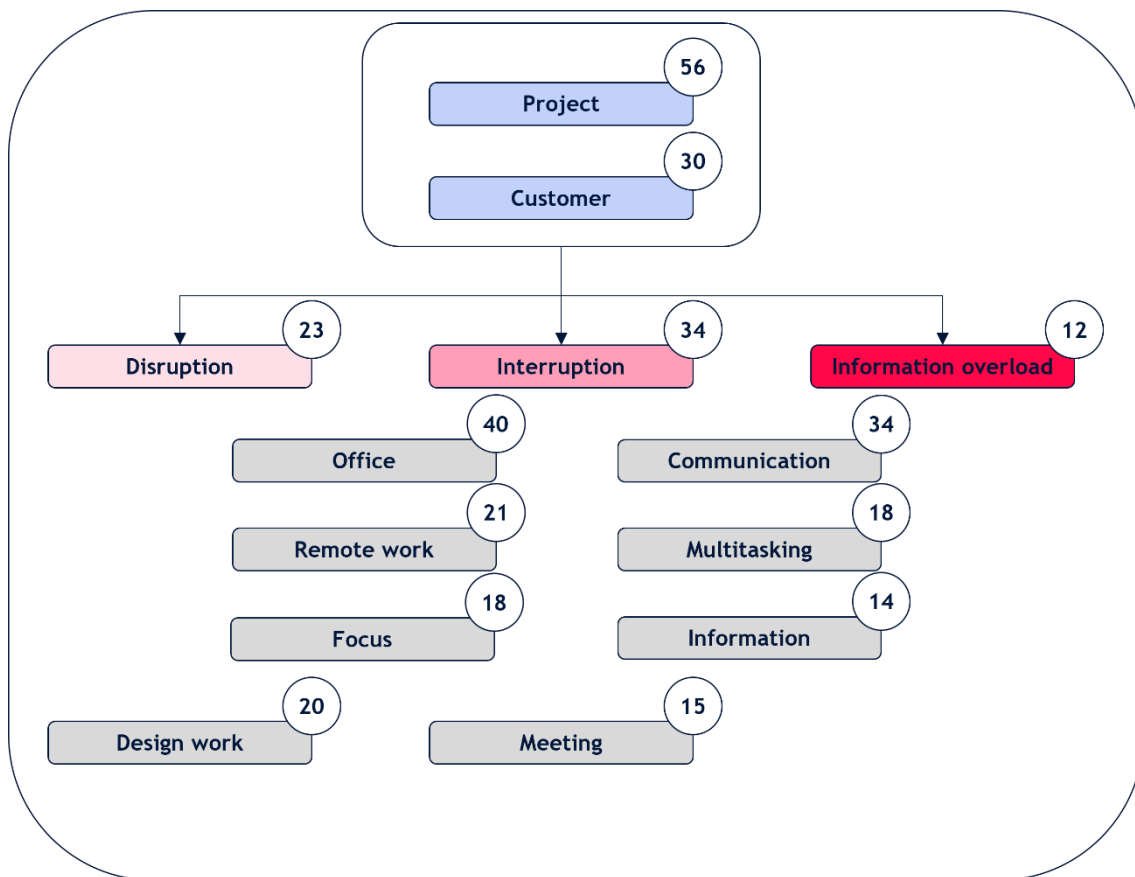
Theme *Interruption* occurred the most of the cognitive strain themes in the interviews, in total 34 times, it was evenly occurred theme in both, Mechanical Designer and Project Manager interviews. The interruption theme also had most other themes in the same answers, and discussions in the interviews. *Interruption* was mentioned together with the *Office* (40), *Communication*, (34), *Remote work* (21), *Multitasking* (18), *Focus* (18), *Meeting* (15), and *Information* (14). *Interruption* was seen as *disruption* what comes to the office environment, and challenges for focusing the work, especially in the open office spaces. The challenges related to office work are also colleagues asking for help or starting another discussion, not relevant to the work. However, interruptions are not limited only to face-to-face situations. The remote work, and that way a heavy usage of online interaction tools is seen also quite challenging for the daily work, communication with the interaction tools can in some cases be even more straightforward and cause interruptions for the employees during their work. Also, the need of wait for certain information from customer, project manager, or other relevant person before moving to the next task can cause interruption for the employee's work, and further on that can cause multitasking, if need to hop on from one task to another to have something to work with. Meetings are sometimes seen as interruptions to the work.

For this thesis interview, there were an interruption for one of the respondents during the interview, which caused a cut for the interview flow, due to that one of the planned questions for the interview were not asked, which came up during the transcribing process. For the interview, it had only a minor effect, but it was another reminder of the possible issues that interruptions can cause. Interruptions were experienced as the second severe source of cognitive strain among the *disruptions*, *interruptions*, and *information overload*.

Theme *Information overload* occurred the least number of times of the cognitive strain themes in the interviews, in total 12 times. Information overload was mentioned together with *Communication* (34), *Multitasking* (18), and *Information* (14). *Information overload* was mentioned more often in the Project Manager interviews, but also it occurred in the Mechanical Designer interviews. *Information overload* was seen as a severe source of cognitive strain, the challenge with it was working in parallel with multiple tasks or projects, amount of information to be processed, endless notifications of the interaction tools, multiple projects and the information related to them. Challenges with information overload were also seen correlative to the number of projects, the more projects the more information to process. Also, sometimes the employees can create *information overload* by themselves by focusing on podcasts or such during their work, by their own choice.

During the interview, one respondent was concerned about the Teams notifications that were appearing to his Teams application during the interview, it had a negative impact on his ability to focus on the interview. What was interesting in the interview was that the *information overload* was experienced as the most severe source of cognitive strain from the disruptions, interruptions, and information overload. Even still, there were the least mentions of it in the interviews. *Information overload* can be more of an abstract factor, and the employees do not have tangible or functional ways to tackle it, that can be the reason they did not mention it so often in the interviews. Further to that, *information overload* is not limited to work only, the risk for *information overload* is everywhere and all the time for everyone who is using modern technology in their daily lives.

To conclude this chapter, below is a theme map (Figure 7.) which shows the themes identified in the interviews illustrated in the grey boxes, theme occurrence quantities which are illustrated with the white balls, and the context how they were mentioned related to each other is illustrated with horizontal placement in the map. The Project and Customer are high-level themes, related to all cognitive strain sources. The color of the cognitive strain sources indicates the experienced severity among the respondents, the darkest red is the most severe and the lightest red is the least severe. Based on the interview results information overload was the most severe, then interruptions, and the least severe source of cognitive strain was disruptions in the interview respondents' daily work.



**Figure 7: Interview theme map**

## 6 Discussions and Conclusions

### 6.1 Discussions on the results and findings

This chapter reviews the pre-selected research questions of the study and gives the answers for them based on the interview results, which are contrasted to the theory background. In the end of the chapter is a research question map (Figure 8.) compressing the findings to a figure. The research questions seemed to be well defined and relevant for the study, there can be seen a natural link in between the research questions and answers. The research objectives can be fulfilled based on the chosen research questions and results gained through them. Additionally, there are discussions and suggestions for future research presented in this chapter.

#### 6.1.1 Definitions and factors of a good performance level

The case company has a wide variety of competences in their talent pool, and due to that it is seen challenging to have a holistic definition for the knowledge work performance in a company level. Further to that, there are no systematic, proactive measurement methods to track whether the employees are performing well or not. This finding is aligned with the study by Palvalin et al. (2015), since currently, even the science field does not have universally accepted methods for the individual knowledge worker performance measurement. This study focused on one of the three competence areas of the company, the Product Design Center of Excellence. In that center there are identified two tangible factors to evaluate the performance of knowledge workers, which are the *sufficient level of quality for work* and *staying in a schedule in assigned work tasks*. However, if observing the performance from a productivity point of view, these two factors defined in the case company are 2 out of 13 factors that Ramirez and Nembhard (2004), presents in their research. Their list of productivity contains quantity, economic factors, timeliness, autonomy, quality, innovation/ creativity, customer satisfaction, project success, efficiency, effectiveness, responsibility/ importance of work, knowledge worker's perception of productivity, and absenteeism. Also as identified in the case company, their performance definition factors quality and schedule have their problems, since the root cause for the lack of quality or stretched schedules can be caused by failed resourcing of the project or failed offer for the project, which in practice can be a not matching competence level of knowledge worker for the assigned work task requirements, or too optimistic project schedule and too little working hours sold for the

work packages. The quality and time can be a functional factor for performance definition but require a closer evaluation in each case. Further, as Takala et al. (2006), proposes in their research, performance of knowledge work should be carried with wider perspective, containing four aspects that are results, process, behavior, and physiology. They indeed argue that because the knowledge work characteristics, that is needed, as the knowledge work is non-repetitive, output of knowledge work is impacted with many external factors, output of knowledge work is difficult to quantify, and most knowledge workers performs best in collaboration with others.

In general, outputs and inputs of knowledge work are intangible and complex. What comes to the performance measurement in the case company, in the most cases, the performance evaluation of the employees comes from a "gut-feeling" and is intuition based. The signals of varying performance of each employee can be identified from the colleague feedback, but mostly from the customer feedback which is rarely available. This method of considering colleague and customer feedback is a good start and that would be good to strengthen and further organize. As in Jääskeläinen and Laihonen (2013), research, they propose a method of multiple evaluators for knowledge work performance evaluation, including self-review and peer reviews additionally to superior review, additionally to that, as very important factor, customer review with not limited only to customer satisfaction, but rather with multiple measurement criteria of service outcomes.

### 6.1.2 Cognitive strain and ways to maintain cognitive ergonomics

In the knowledge worker interviews, all the identified sources of cognitive strain mentioned in theory background had occurred in the respondent's daily work. The order from most severe to least severe strain source was mentioned among the respondents as Information overload, Interruptions, and Disruptions.

Information overload was the most severe source of cognitive strain among the respondents, the number of projects is often seen as correlated to the challenges with information overload; in more detail the multitasking, working in parallel with multiple projects and need to change from a task to another and back. This is also identified by Couffe and Michael (2017), and their research underlines that switching from task to another task creates a disengagement of attention for the primary task and can generate interference with the ongoing goals that should be maintained. The interview results also included communication information, endless notifications from the interaction tools, and large amount of information to be processed as negatively affecting factor. That was also seen in Kalakoski et al. (2020) and Roetzel (2017), research where they presented that new interaction technologies with constantly appearing notifications, having too many messages to handle, and not knowing whom instructions to follow can bother employee's focus on work and hinder the task performance. Additionally, sometimes the employees can generate the information overload by themselves, if listening to podcasts or such during their work. As Costas and Kärreman (2016) states in their research, knowledge work requires a high degree of self-organization abilities by the employees, especially when the work structure is open, and work is performed outside of the direct supervision of management.

The way to manage the information overload by the respondents is to try to limit the number of projects, delegating tasks, or asking for help and extra resources to projects, writing down with pen and paper the backlog or task lists, and prioritizing the work, closing the interaction tools, or changing the personal status for "do not disturb" – mode in the Microsoft O365-environment.



Interruptions were the second severe source of cognitive strain among the respondents. The interruptions are mostly caused by colleagues, who are interrupting the focus with help requests, or other non-work-related matters. The interruptions can be caused either at the office environment or remotely via Teams software, phone-calls, or e-mails. Sykes (2011) had also identified these to be main sources of interruptions in his research. His research has identified that main sources of interruptions are messenger messages, emails, phone-calls, and colleague interaction. Especially helping colleagues with issues is identified to be very time-consuming in his research. In the interview results, interruptions to the work can also be caused by waiting for certain information, for example decisions or instructions that are needed to move forward with your own tasks. Repo, Ravantti and Pääkkönen (2015) had similar findings, as they stated that interruptions can be an organizational related factor, when employee's need to wait for decision or information that will cause a delay for task completion.

However, the way to manage the interruptions by the respondents is to work remotely to minimize the colleague interruptions, closing the interaction tools, or changing the personal status for "do not disturb" – mode in the Microsoft O365-environment, reserving own calendar slots as a blocker so that no meetings can be booked to the calendar when there is a need to focus on certain tasks. When waiting for certain information or decision to be able to move forward with own tasks, there was no practical solution identified, but to trying to ask after it from the person in charge of the information or decision.

Disruptions were the least severe source of cognitive strain among the respondents. The disruptions were mostly caused by things linked to the office environment, such as sounds, movements, and noise in the office environment. This is in line with the research of Bridger and Brasher (2011), where they identified that open-office premises disruptions caused frustration and self-control demand. Also, Kalakoski et al. (2020), stated that disruptions in the working environment affect the employee ability to master cognitively demanding tasks. According to the interview respondents, disruptions are seen more as an annoying thing, that will challenge an employee's ability to focus on their work. Jahncke et al. (2011), found out in their study that disruptions caused cognitive strain which led to decreased memory capacity, feeling of tiredness, and decreased working motivation. The way to manage the disruptions by respondents is to work remotely to minimize the disruptions that are occurring especially in the open office premises.

Additionally, other ways to reduce cognitive strain, not directly related to any of the cognitive strain sources is to have short micro-breaks and go for example to a little walk outside at the home office. Jahncke et al. (2011), also highlights the importance of having micro-breaks during the day. Also, doing small housework tasks, emptying the washing machine and such was seen helpful to settle the thoughts of the respondents. Having a conversation with a colleague or superior about the situation to have sparring, new points of views, or other help was also seen useful among the respondents. In general, as Palvalin et al. (2015), defines in their research, individual work practices and behaviors are important to be supported by the organization, where everything cannot be structured and organized from top-down management methods.

### 6.1.3 Affects of cognitive strain on knowledge work performance

The determined good performance level in this case can be seen as a sufficient quality of work and staying on a schedule. The respondents identified several tangibles, and easily understood things that how cognitive strain affects the good performance level. According to the respondents, cognitive strain affects the quality of work by increasing human errors and mistakes, e.g., by increasing the design failures or probability of forgetting things. This is also identified by Kalakoski et al. (2020), that cognitive strain has harmful consequences for task performance by attention failures, which harms the workflow and may negatively affect productivity. Also, Sykes (2011), identified that cognitive strain may lead to additional stress and lead employees to likely make errors.

Additionally, interview respondents said that the cognitive strain affect to the ability to create new ideas or innovate new solutions, also the overall quality of work can decrease on purpose, if the employee just wants the easy way out from the assigned tasks to survive and complete them in time. This is well aligned with Kalakoski et al. (2020), research, where they define that well managed cognitive balance affects positively on memory, creativity, and ability to manage the large and complex entities. Schedule-wise the cognitive strain may increase the number of unfinished tasks or increase the difficulty of decision-making which can cause stretched schedules for the projects. This is also mentioned in Baether and Rigotti (2013) research, where they found that cognitive strain may cause unfinished tasks which led to time-pressure and can cause irritation and dissatisfaction with employee's own work performance.

Based on the interview results, there were mentioned negative impacts on the work itself, but also a negative impact that can affect to the work-life balance, when the cognitive strain is affecting to the energy levels outside of the work due to the work-based stress. As Riikonen et al. (2003) has identified in their research, cognitive strain can have negative impacts on the overall well-being of the employee, e.g., raise the level of anxiety and mental illness.

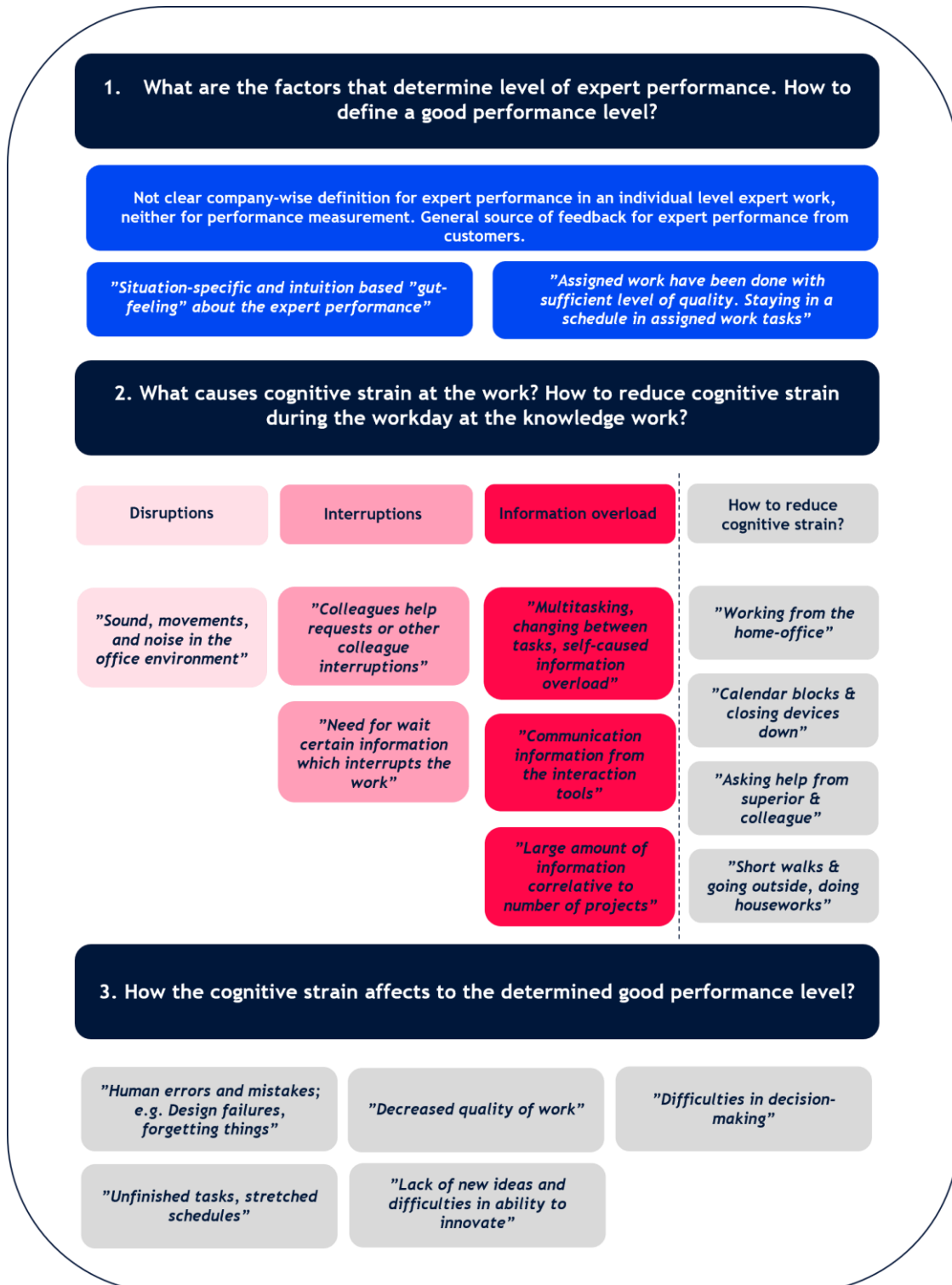


Figure 8: Research questions map

## 6.2 Suggestions for future research

Based on the study, including theoretical background and both managerial, and knowledge worker interviews, this chapter presents suggestions for future research. The future research suggestions could be either executed as thesis works, or internal development projects.

Could be beneficial for the company to understand more in depth, how could the knowledge worker performance definition be agreed in a company level, which factors of the performance are the most important to be enhanced, and how to monitor, manage, and support the ability to perform well in the knowledge work. This is linked to the employee well-being and cognitive ergonomics but could be studied solely to create a baseline for the performance definition in the company.

In the interviews there were few mentions about the renewed organizational structure, that is decentralized, and location free. Would be good to understand the consequences of the organizational change, now that there are some years of experience of the new organization structure. In the interviews there were both positive and negative experiences related to that. Freedom of location was seen very good due to the possibility of remote work. However, some respondents also stated that when working in a distant team, without knowing each other in person and co-working only over the internet can cause inefficiency for the work, lack of interest to go to the office environment if there is none with whom you are sharing common projects, or even a weakened engagement towards the team. Understanding the strengths and weaknesses of decentralized organization structure, exploiting the benefits, and mitigating the negative impacts could be beneficial for the company.

A general study could also be beneficial to conduct where the open office environment and remote work efficiencies could be compared in between each other. Understanding in more detail what are the things in the working environment that the employees need to be able to perform well in their work. Could be interesting to know, would it be more cost-effective to invest in employees' home-offices rather than the office premises. As one respondent stated, that would be interesting to know the cost of interruptions, how often they occur and for how many employees. Finding out the estimate of cumulative time and cost losses could be eye-opening.

In the interview, there were also couple mentions of the invoicing percentage measurement, playing an important role in the company operations. It is also visible for the employees and was a worrying element for some of the respondents. However, for example as Landers, Rebitzer and Taylor (1996) have identified in their research, promoting, and rewarding employees based on the billable work hours might decrease the work efficiency and lead to the inefficient work, and so-called work-hour picking. Could also be beneficial for the company to research, is there a possibility for the company to transform from an invoicing percentage-oriented culture to another, perhaps more engaging, efficient, and rewarding operating system.

There are certainly more future research possibilities regarding this study field, here are just a few suggestions that have been pointed out based on this study. In general, it is a sign of a healthy company culture, when new knowledge is being created via different methods, such as final thesis opportunities for students and employees studying besides the work. This study has its value as is but offers also new opportunities for future researchers interested in exploring this important study field, that can offer game-changing opportunities to the organizations and companies operating in knowledge-intensive industries.

### 6.3 Practical implications

In this chapter is presented possible ideas for creating the most cognitively sustainable working environment in the industry, where the sources of cognitive strain are minimized in an organization-level and other actions are taken to take the best possible care of the most important asset of the company, the employees, and their cognitive capability.

1. Raising the knowledge of the topic

Working ergonomics, and employee ergonomics have traditionally been focused on the physical aspects of the ergonomics, meaning that the development and sustaining of working ergonomics have mostly been activities towards the physical environment of the employees, such as workstations, physical recovery with various methods and so on. Physical ergonomics is well needed and valuable, but there is a need to observe the employee ergonomics with a wider perspective. In the knowledge-intensive organizations as the case company purely is, the cognitive ergonomics is playing crucial role in the employee's daily work, affecting directly to the company-level success, not only from monetary aspect, but also what comes to the employee's well-being, mental health, and employee engagement.

Knowledge of the topic is important to be raised at all levels of the company, from the top management to each individual employee. Engaging the whole working community in the early stages of raising the knowledge of the topic and understanding what kind of consequences the cognitive strain can create, and how would the cognitive ergonomics be utilized in developing the organizational culture towards cognitively sustainable, effective, and high performing is important. Raising awareness of the topic, both how to define the good working performance and what causes cognitive strain at work will be the first steps in the transition and following that, mapping out the most suitable actions for the company to start will create a good base for the cognitively sustainable organization where one can success and perform well.

## 2. Educating the management and employees about the topic

More in depth, continuing the previous chapter, the education about the topic could start with the management level, and further to that be put into practice throughout the whole organization. There is extensive research about this topic, for example conducted by Työterveyslaitos, they have researched knowledge work and cognitive ergonomics, leadership of hybrid work, and other relevant things related to cognitive ergonomics. Työterveyslaitos has a course “Sujuva aivotyö – verkkoalumnus”, which educates topics such as what is knowledge work and its characteristics, how to identify the boundaries and enablers of knowledge work, how to manage the cognitive strain sources and fluency the knowledge work with tangible tips and techniques, and in general widening the perspective of how the organization could solve the challenges of knowledge work (Työterveyslaitos, 2023). As mentioned in the interviews, the company has reserved an annual budget for employees’ education, so these courses could be suggested for the employees as a general education.

Education of the whole organization would help to identify the sources of cognitive strain and give understanding of how to sustain the cognitive balance. That could also increase the maturity of the self-leading capabilities of employees and give more practical tools for people working in managerial positions of the company.



### 3. Office environment development

The office environment could have commonly agreed rules that could enhance the ability to focus for the employees. Especially, when the office environment is an open plan office, it is very important to have common rules due to the shared space. In the offices there could be commonly agreed silent hours for certain hours or days, e.g., Every Tuesday – Thursday silent hours until 09.00 in the morning coffee, when all not necessary discussions aren't allowed. Meetings are of course something that cannot be affected. Also, other rules, for example, no cellphones to coffee rooms on certain days could be beneficial for the recovery from work, and for the work community in general. All these rules or common etiquette of course agreed together with the working community. Additionally, what comes to the work environment, the lay-out planning could consider the different needs of different positions, perhaps some of roles e.g., design and development professionals might need more silence and calmness, when the sales and project management professionals then need more of pitching partner or communication. Dividing the office areas based on the roles and individual needs of personnel could be helpful for the professionals to have the best possible experience of working at the offices.

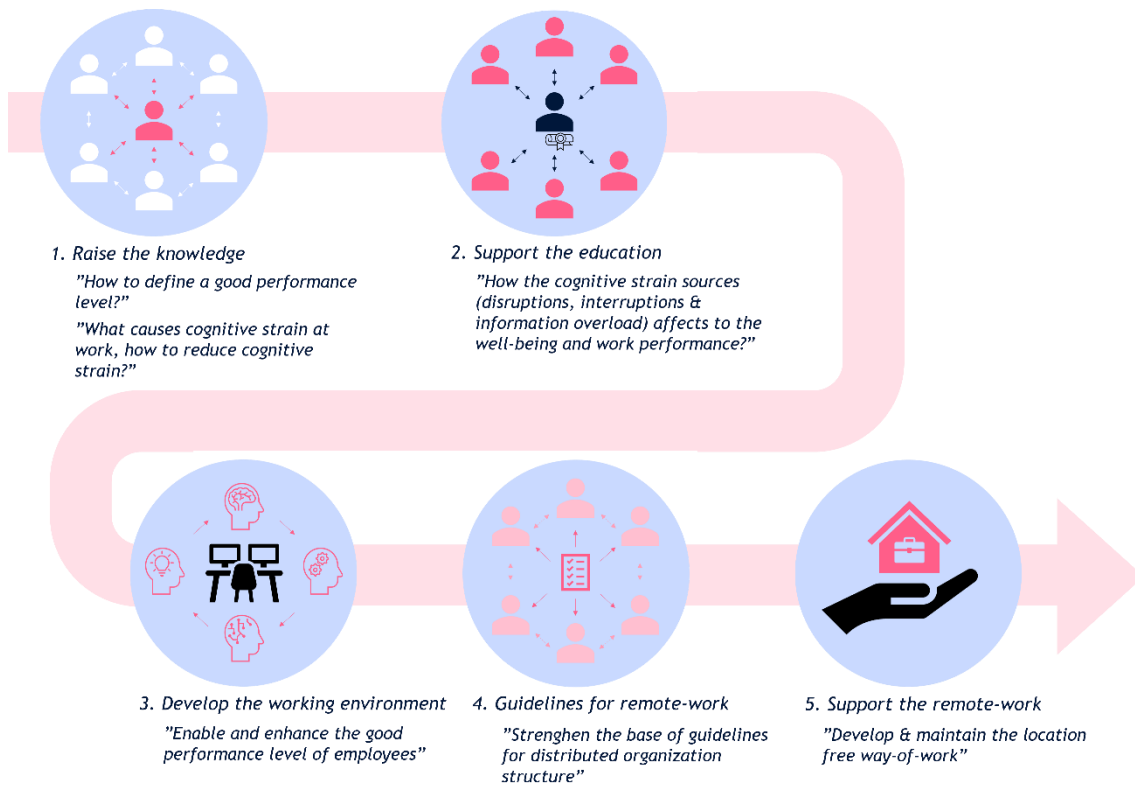
#### 4. Common guidelines for remote working

Remote working and hybrid-work is here to stay; however, common etiquette is still to be developed. Remote working gives a lot of room for the personnel to create their own working environment and working habits, but on a down-side it is seen that remote working can sometimes increase the number of interruptions. The ways to use the Teams software or personal calendars are nowadays mostly driven by personal needs and habits, but no general guidelines are available. Guidelines for the remote working and usage of interaction tools could be helpful for the personnel, when and how to contact your colleagues, how to signal for others that no interruptions are allowed, how to reserve your own focus hours from the calendar and so on. Common guidelines could be helpful for all parties of the organization when working in a distributed organization structure.

#### 5. Supporting the remote work

In the interviews, it was clear that all the respondents valued the location free work and wanted to keep working on a hybrid model also in the future. The hybrid model work and working from the home-office was seen very good due to multiple reasons, even if it meant that the physical ergonomics at the home office were poor compared to the office environment. Roughly said, respondents wanted to choose the cognitively sustainable environment over the physically sustainable environment. However, considering the working ergonomics as a larger entity, it could be good to support the employees to build up their own workstations for the home-office. In the easiest level, there could be available ergonomic furniture in the reward shop for the employees to choose. Developing and maintaining the location free work could also be more cost effective from a financial perspective.

The following roadmap (Figure 9.) is compressing the presented suggestions for how to develop the most cognitively sustainable working environment in the industry. The roadmap is built in chronological order starting from building the foundations of the transformation by raising the knowledge of the topic in the organization, and after that offering the possibility and supporting everyone in the organization to educate themselves around the topic with internal or third parties' help. Furthermore, there are more detailed suggestions for how to develop the physical and virtual working environment in the company by developing the office environment spaces and practices, guidelines for distributed organization structure, and finally, how to support holistically the location free, way-of-work for the employees, who are willing to conduct their work from the home-offices.



**Figure 9: Roadmap for cognitively sustainable organization**

## 6.4 Conclusion

This thesis was about cognitive strain and ability to perform well in knowledge work. Also, it was discussed how cognitive ergonomics could help the employees to perform well in their work, as well as increase their overall well-being. The thesis started with introduction of the thesis, which followed the background of the case company, theoretical background around the topic, chosen methodology for the research setting, results and analysis, which led to the final chapter of discussions and conclusions.

The study findings show that the cognitive strain has an impact on the employee's performance based on their own evaluation. The information overload was experienced as the most challenging, interruptions as secondly, and disruptions as the least severe source of cognitive strain. Also, cognitive ergonomics was seen as an interesting, but not so well-known topic among the interviewee respondents. However, the sample size what comes to the number of respondents is rather small, only one case company and 5 knowledge worker respondents. This research cannot give a holistic understanding of the researched topic but gives a deeper understanding of the respondent's point of view and experiences. The results and analysis can reflect the experiences of a bigger population, but based on this study the generalizations of the results are not recommended. One of this research take-aways can be stated, that the respondents of this study wanted to choose cognitively ergonomic working environment over the physically ergonomic working environment, due to the reason that their work requires an ability to focus with minimum amount of possible cognitive strain sources.

To conclude, there are several future research opportunities around this topic, in general, this research topic is in early stage of maturity in the field of industrial management and that way could offer interesting intersectoral research opportunities for future researchers. Hopefully this thesis can also inspire its readers to find other relevant research topics to be further studied.

## References

Alasuutari, P. (2011). Laadullinen tutkimus 2.0. Vastapaino, Riika, 2011. (s. 1-316)

Baethge, A., & Rigotti, T. (2013). Interruptions to workflow: Their relationship with irritation and satisfaction with performance, and the mediating roles of time pressure and mental demands. *Work & Stress*, 27(1), 43-63. <https://doi.org/10.1080/02678373.2013.761783>.

Bridger, R. S., & Brasher, K. (2011). Cognitive task demands, self-control demands and the mental well-being of office workers. *Ergonomics*, 54(9), 830-839. <https://doi.org/10.1080/00140139.2011.596948>.

Charalampous, M., Grant, C. A., Tramontano, C., & Michailidis, E. (2019). Systematically reviewing remote e-workers' well-being at work: A multidimensional approach. *European Journal of Work and Organizational Psychology*, 28(1), 51-73. <https://doi.org/10.1080/1359432X.2018.1541886>.

Costas, J., & Kärreman, D. (2016). The bored self in knowledge work. *Human Relations*, 69(1), 61-83. <https://doi.org/10.1177/001872671557973>.

Couffe, C., & Michael, G. A. (2017). Failures due to interruptions or distractions: A review and a new framework. *American journal of psychology*, 130(2), 163-181. <https://doi.org/10.5406/amerjpsyc.130.2.0163>.

Duggan, G. B., Johnson, H., & Sørli, P. (2013). Interleaving tasks to improve performance: Users maximise the marginal rate of return. *International Journal of Human-Computer Studies*, 71(5), 533-550. <https://doi.org/10.1016/j.ijhcs.2013.01.001>.

Groen, B., van de Belt, M. and Wilderom, C. (2012). "Enabling performance measurement in a small professional service firm", *International Journal of Productivity and Performance Management*, Vol. 61 No. 8, pp. 839-862. <https://doi.org/10.1108/17410401211277110>.

Haavisto, M-L. (2006). Kognitiivinen ergonomia lisää työn sujuvuutta ja turvallisuutta. *Työterveyslääkäri-lehti*, 24(3), 24-27. Retrieved February 23, 2023, from <https://www.terveysportti.fi/apps/dtk/tyt/article/ttl00351/search/kognitiivinen%20ergonomia%20lis%C3%A4%C3%A4>

Gino, F. (2016). *Are You Too Stressed to Be Productive? Or Not Stressed Enough?* Harvard Business Review. Retrieved January 20, 2023, from <https://hbr.org/2016/04/are-you-too-stressed-to-be-productive-or-not-stressed-enough>

Huotilainen, M. and Moisala, M. (2018). *Keskittymiskyvyn elvytysopas*. Otavan Kirjapaino Oy, Keuruu, 2018. (s. 1-126)

International Ergonomics Association. What is ergonomics? Retrieved January 10, 2023, from <https://iea.cc/about/what-is-ergonomics/>

Jahncke, H., Hygge, S., Halin, N., Green, A. M., & Dimberg, K. (2011). Open-plan office noise: Cognitive performance and restoration. *Journal of Environmental Psychology*, 31(4), 373-382. <https://doi.org/10.1016/j.jenvp.2011.07.002>.

Jääskeläinen, A., & Laihonen, H. (2013). Overcoming the specific performance measurement challenges of knowledge-intensive organizations. *International journal of productivity and performance management*, 62(4), 350-363. <https://doi.org/10.1108/17410401311329607>.

Kalakoski, V. (2018). Kognitiivisella ergonomialla sujuvaa, tuottavaa ja terveellistä työtä. Retrieved February 21, 2023, from <https://www.tietojohtaminen.com/sites/default/files/2018-5-ta-kalakoski.pdf>

Kalakoski, V. (2019). Cognitive Ergonomics is a Matter of Cognitive Factors. In *ReCogErg@ ECCC* (pp. 46-51).

Kalakoski, V., Selinheimo, S., Valtonen, T., Turunen, J., Käpykangas, S., Ylisassi, H., ... & Paajanen, T. (2020). Effects of a cognitive ergonomics workplace intervention (CogErg) on cognitive strain and well-being: a cluster-randomized controlled trial. A study protocol. *BMC psychology*, 8(1), 1-16. <https://doi.org/10.1186/s40359-019-0349-1>.

Landers, R. M., Rebitzer, J. B., & Taylor, L. J. (1996). Rat race redux: Adverse selection in the determination of work hours in law firms. *The American Economic Review*, 86(3), 329. Retrieved from <https://www.proquest.com/scholarly-journals/rat-race-redux-adverse-selection-determination/docview/233015191/se-2>

Lazar, J., Feng, J., Hochheiser, H. (2017). *Research Methods in Human Computer Interaction* (Second Edition). Morgan Kaufmann, 299-327. <https://doi.org/10.1016/B978-0-12-805390-4.00011-X>.

Meyer, S. C., & Hünefeld, L. (2018). Challenging cognitive demands at work, related working conditions, and employee well-being. *International journal of environmental research and public health*, 15(12), 2911. <https://doi.org/10.3390/ijerph15122911>.

Muistiliitto. Hyvä työ aivoille. Retrieved January 26, 2023, from <https://www.muistiliitto.fi/fi/aivot-ja-muisti/aivoterveys/hyva-tyo-aivoille>

Paajanen, T. & Kalakoski, V. (2017). Mitä työterveyslääkärin tulisi tietää kognitiivisesta ergonomiasta? *Työterveyslääkäri-lehti* 35 (2), 16-21. Retrieved February 23, 2023, from <https://www.terveysportti.fi/apps/dtk/tyt/article/ttl01557/search/mit%C3%A4%20ty%C3%B6terveysl%C3%A4%C3%A4k%C3%A4rin%20tulisi%20tiet%C3%A4%C3%A4%20kognitiivisesta%20ergonomiasta%3F>

Palvalin, M., Vuolle, M., Jääskeläinen, A., Laihonon, H., & Lönnqvist, A. (2015). SmartWoW –constructing a tool for knowledge work performance analysis. *International journal of productivity and performance management*, 64(4), 479-498. <https://doi.org/10.1108/IJPPM-06-2013-0122>.

Pyöriä, P. (2005). The concept of knowledge work revisited. *Journal of knowledge management*. 9 (3), 116-127. <https://doi.org/10.1108/13673270510602818>.

Ramirez, Y. W., & Nembhard, D. A. (2004). Measuring knowledge worker productivity: A taxonomy. *Journal of intellectual capital*. <https://doi.org/10.1108/14691930410567040>.

Repo S., Ravantti E., Pääkkönen R. (2015). Johda tuottavasti - Opas työhyvinvoinnin ja tuottavuuden lisäämiseksi esimiestyön keinoin

Riikonen, E., Tuomi, K., Vanhala, S. & Seitsamo, J. (2003). Hyvinvoiva henkilöstö – menestyvä yritys. Helsinki: Työterveyslaitos.

Roetzel, P. G. (2019). Information overload in the information age: a review of the literature from business administration, business psychology, and related disciplines with a bibliometric approach and framework development. *Business research*, 12(2), 479-522. <https://doi.org/10.1007/s40685-018-0069-z>.

Röer, J. P., Bell, R., & Buchner, A. (2014). Please silence your cell phone: Your ringtone captures other people's attention. *Noise and health*, 16(68), 34. 10.4103/1463-1741.127852.

Saunders, Mark & Bristow, Alexandra. (2023). 2023 Research Methods for Business Students Preface and Chapter 4.

Sykes, E. R. (2011). Interruptions in the workplace: A case study to reduce their effects. *International Journal of Information Management*, 31(4), 385-394. <https://doi.org/10.1016/j.ijinfomgt.2010.10.010>.

Sørensen, O. H., & Holman, D. (2014). A participative intervention to improve employee well-being in knowledge work jobs: A mixed-methods evaluation study. *Work & Stress*, 28(1), 67-86. <https://doi.org/10.1080/02678373.2013.876124>.

Takala, J., Suwansaranyu, U., & Phusavat, K. (2006). A proposed white-collar workforce performance measurement framework. *Industrial management + data systems*, 106(5), 644-662. <https://doi.org/10.1108/02635570610666421>.

Työterveyslaitos. Aivotyö sujuvaksi. Retrieved February 23, 2023, from <https://www.ttl.fi/oppi-materiaalit/aivotyo-sjuvaksi/aivotyota-tehdaan-yhdessa>



Työterveyslaitos. Sujuva aivotyö – verkkovalmennus. Retrieved May 10, 2023, from <https://www.ttl.fi/koulutus/verkkovalmennus/sujuva-aivotyo-verkkovalmennus>

Vartiainen, M. & Hyrkkänen, U. (2010). Changing Requirements and Mental Workload Factors in Mobile Multi-Locational Work. *New Technology, Work and Employment*. 25. 10.1111/j.1468-005X.2010.00243.x.

Wilson, J. R. (2000). Fundamentals of ergonomics in theory and practice. *Applied ergonomics*, 31(6), 557-567. [https://doi.org/10.1016/S0003-6870\(00\)00034-X](https://doi.org/10.1016/S0003-6870(00)00034-X).

Yerkes, R.M. & Dodson, J.D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology & Psychology*, 18: 459-482. <https://doi.org/10.1002/cne.920180503>.

## Appendices

### Appendix 1. Managerial interview setup; “work performance in the case company point of view”

#### Background information

1. *Age?*
2. *Role?*
3. *Years of experience in the role? (Including previous workplaces)*
4. *Years of experience in the company?*

#### Performance definition

1. *Through which elements the performance of the employee is observed?*
2. *How is good employee performance defined in the company?*
3. *How is employee underperformance defined in the company?*
4. *How would you describe the accuracy of employee performance definition in the company?*
5. *How is employee performance measured in the company?*
6. *How would you describe the accuracy of employee performance measurement in the company?*
7. *What is the company reaction and actions for the good employee performance?*
8. *What is the company reaction and actions for the employee underperformance?*

#### Performance management

1. *How are the employee performance elements prioritized in the company?*
2. *What is the reasoning for this prioritization order?*
3. *What kind of factors have been identified in the company that may have an impact on employee performance?*
4. *How have these factors been identified?*
5. *How does the company support the employees to enhance their ability to perform well in their work?*
6. *How does the company act to minimize the employee underperforming?*
7. *Open comments?*

## **Appendix 2. Knowledge worker interview setup; “Cognitive strain in the knowledge worker’s point of view”**

### **Background information**

1. *Age?*
2. *Role?*
3. *Years of experience in the role? (Including previous workplaces)*
4. *Years of experience in the company?*
5. *What kind of tasks are included in your role?*
6. *In which kind of projects do you usually work on?*
7. *How many projects do you usually have in parallel?*
8. *How many customers do you usually work with in parallel?*

### **Working environment & tools**

1. *Do you have interruptions at your work?*
2. *If so, what causes interruptions at your work?*
3. *Do you have disruptions at your work?*
4. *If so, what causes disruptions at your work?*
5. *Is the amount of information feasible at your work?*
6. *If not, do you have information overload at your work?*
7. *If so, what causes information overload at your work?*
8. *Do you have to multitask at your work?*
9. *If so, what causes multitasking at your work?*
10. *What kind of tools do you have to use at your work?*
11. *Do you have a feasible number of tools at your work?*
12. *Do you work at the office premises or at the home office?*
13. *If at a hybrid-model, what is the percentage rate of your choice for work environment setting?*
14. *What has affected your choice of work environment setting?*

**Cognitive strain & cognitive ergonomics**

1. *Have you had cognitive strain at your work?*
2. *If so, what has generated cognitive strain to you?*
3. *If so, which of these things you mentioned, has generated the most cognitive strain to you?*
4. *How does cognitive strain affect you?*
5. *Do you have your own routines to mitigate cognitive strain at your work?*
6. *How do you think your organization is helping you in maintaining cognitive balance?*
7. *Do you think your organization could improve in helping the employees to maintain their cognitive balance? How?*

**Performing in the work**

1. *Do you think cognitive strain affects your working performance?*
2. *For which factors of your performance cognitive strain affects the most?*
3. *Open comments?*