

MASTER

Business Case Healthy Offices

Insights in the effects of the physical work environment on mental health+ and organizational performance

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GRADUATION PROJECT

Business Case Healthy Offices

Insights in the effects of the physical work environment on mental health+ and organizational performance

MSc Urban Systems & Real Estate
D.J. (Daan) Kropman (0891677)
June 2021

DEPARTMENT OF THE BUILT ENVIRONMENT

Business Case Healthy Offices

Insights in the effects of the physical work environment on mental health+ and organizational performance

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The Master's thesis has been carried out in accordance with the rules of the TU/e Code of Scientific Integrity. The information in this thesis is publicly accessible.

Preface

I have always been fascinated by the idea that everything around you is created according to a certain plan or vision. During the study in Eindhoven, you learn to understand why the built environment is the way it is, why and how areas and buildings are developed, and how these huge elements can have an impact on so many different levels. Buildings can provide people with a sense of home, make them feel happier, encourage social interactions, and create a healthy environment to live in.

These insights inspired me to focus on the healthy work environment where an office not only provides a roof to work under, but supports its users by providing a comfortable and healthy workspace. However, interventions in real estate that aim to do so are scarce due to the lack of insights in the added organizational value of these investments. This motivated me to study the effects of changes in the physical workspace on mental health and organizational performance during my master thesis. Over the past 8.5 months, I have been working on my graduation project and I can say that I am very satisfied with the result as well as the entire process from start to finish. And for that, I would like to thank several people.

First of all, I would like to thank my graduation committee, Rianne, Pascale and Lisanne for their excellent guidance, feedback and knowledge over the past months. I could not have delivered the same level of quality without your help. In addition, I would like to thank Susanne and Sergé for their help and business insights during my graduation internship at Royal HaskoningDHV.

Next, thank you Alissa, Bauke, Bouke, Carmen, Ellen, Laura, Marieke, Martijn, Merel, Niels, Puck and Sven for all the great moments and memories over the past years at TU/e.

Finally, I would like to thank Sophie and my parents and brother for all the support, motivation and necessary distractions during my studies.

After finishing my graduation project on the 22nd of June, I will complete my MSc. Urban Systems & Real Estate at Instituto Superior Técnico in Lisbon in the upcoming six months. I look back at my student days at Eindhoven University of Technology as a wonderful time full of activities and memories and I look forward to all the new events and opportunities in my future career.

Daan Kropman

June, 2020

Summary

The physical work environment plays a role in employee mental health. This thesis addresses so-called mental health+, which consists of ten work-related mental health concepts: *individual productivity, concentration, stress, sleep quality, mood, fatigue, well-being, depression, engagement, and burnout*. As a (mentally) healthy workforce is a vital aspect for an organization's success, it is important to optimize the conditions within the office. Investments in employee mental health+ through improving the physical workspace are however not very common, since little is known on the organizational benefits that result from these investments. This study therefore aims to explore the relations between the physical work environment, employee mental health+ and organizational performance, and to use this information to develop a business case tool indicating the potential added organizational value of changes in the physical work environment that could improve mental health+. The main research question is therefore: *How can changes in the physical work environment, that could positively affect employee mental health+, be collated into a business case tool, showing the potential added value of workplace design alternatives for office organizations?*

In an answer to the research question, a business case tool was constructed based on findings from a literature review on the effects of mental health+ on organizational performance and a systematic literature review on the relationships between the physical work environment and mental health+. The business case tool allows CRE managers to assess both the current workspace and design alternatives on their impact on employee mental health+. Furthermore, insights are provided in the effects of changes in the physical workspace on performance KPIs, via improved mental health+ concepts.

Results of the 133 studies resulting from the systematic literature review indicated that respectively *light & daylight, office layout & office design, and temperature & thermal comfort* affect most mental health+ concepts, particularly with respect to the concepts *stress* and *productivity*. In turn, the literature review showed that enhanced mental health+ mainly affects the internal business processes of an organization (*absenteeism, communication, job satisfaction, performance, presenteeism and staff turnover*) together with employee growth (*innovation and flexibility*). In the long term, these improvements might lead to higher customer satisfaction, revenue growth and reductions in healthcare and recruitment costs.

The current research has some limitations. First, as one of the objectives was to present an overview fully based on academic literature, optimal workplace standards in this research could deviate from workplace standards applied in practice. Moreover, due to the growing body of research on mental health in the workplace, workplace standards presented in this study could become obsolete over time due to the development of new technologies or workplace standards and should thus be frequently evaluated. Furthermore, the magnitudes of effects presented in this study are subject to subjective (e.g., personal preferences and satisfaction) and situational (e.g., local climate) factors and, thus, cannot be generalized. Practical implementation of the tool should therefore always take place in consultation with the organization of interest. Finally, correlations between components within the physical work environment (e.g., office layout and background noise) or between mental health+ concepts (e.g., sleep quality and mood) are not considered, as well as implementation costs of workplace interventions. The latter could support the decision-making process in prioritizing certain interventions that result from the application of the business case tool.

Since this study provides first insights in the relationships between the physical work environment, mental health+ and organizational performance, research outcomes should be (cross-)validated. Therefore, case studies are needed in which the factors presented in this study are more closely monitored. Additionally, besides the physical workspace, mental health+ is also affected by organizational culture and leadership within an organization. It is therefore important to gain insights in the extent to which mental health+ can be improved by the physical workspace in comparison to corporate culture and leadership.

The lack of insights in the potential added organizational value currently prevents employers from investing in mental health+ by improving the physical work environment. Consequently, measures to optimize the workspace in order to support mental health+ are perceived as an expense rather than an investment, despite the general understanding that a healthy workforce is crucial to an organization. By providing first insights in the potential added organizational value of a healthier workforce, the business case tool presented in the current research enhances the transition where workspace interventions are no longer perceived as expense but as an investment.

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1. Introduction

This chapter introduces the study objectives regarding employee mental health+ in the physical work environment and provides a general understanding of the research area. The chapter starts with a discussion of background information and an explanation of the research gap. Next, the aim of the study is discussed. Furthermore, the relevance of the study is mentioned as well as the outline of the thesis.

1.1 Background

Recent data show that in the Netherlands, the number of people who experienced burnout-related mental health issues due to stress and work pressure was 1.3 million in 2019 (TNO, 2019) and has increased over the last years, from 13.4% in 2015 to 17.0% in 2019 (CBS, 2020). It is therefore only logical that the interest in employee mental health in the work environment is increasing (Hanc et al., 2019). Statistics on stress and burnout-related issues in the work environment do however only discuss a fraction of the entire understanding of mental health. Apart from extreme issues or effects that can be caused by a poor mental state, mental health is a much broader concept regarding a person's entire functioning (Harvard Health Publishing, 2008; WHO, 2004). Seligman (2008) proposed the field of positive health, which refers to "*a state of well-being that goes beyond the mere absence of disease or illness*" (Seligman, 2008 p. 3). Based on this broader definition of mental health, Bergefurt et al. (2021) introduced the concept mental health+, which is defined as a combination of ten mental health concepts specifically within the work environment context: *individual productivity, concentration, stress, sleep quality, mood, fatigue, well-being, depression, engagement, and burnout*.

A large share of employers recognizes the value of their employee's mental health. Approximately 40% of these employers also take precautions that focus on dealing with mental health-related issues (e.g., coaching, health-checks, yoga classes) (RIVM, 2014). However, one of the contributors to these issues, the physical work environment (Chadburn et al., 2017; Cobaleda Cordero et al., 2019; Thatcher & Milner, 2014), is not very often dealt with. Investments in optimizing the physical work environment are rarely made and corporate real estate strategies in the past were solely based on short-term cost reductions and efficiency (Lindholm & Leväinen, 2006; Singer et al., 2007). According to the RIVM (2014), the Dutch national institute for public health and environment, the absence of information and insights in the costs and benefits as well as the effectiveness of such investments is one of the main reasons that withholds an organization from investing in the physical workspace to support employee's mental health.

In a scoping review on mental health+ in the workspace, Bergefurt et al. (2021) identified 133 papers that focus on how one or several mental health+ concepts are affected by the physical work environment, indicating a potential relationship between the physical work environment and employee mental health+. Based on an earlier publication by Al Horr et al. (2016), Bergefurt et al. (2021) refer to the work environment in terms of *office layout & office design; look, feel & color; biophilia, greenery, views & plants; temperature & thermal comfort; noise, acoustics & privacy; indoor air quality & ventilation; light & daylight* (Bergefurt et al., 2021).

In addition, various studies have explored the added value of improved mental health+ concepts for organizations, where results indicate that an improved mental state may enhance individual and organizational performance, providing value to organizations (Riba Sagar et al., 2019; Watson, 2018). With added value, one could think of reduced healthcare costs that result from decreased absenteeism rates, or a boost in an organization's overall performance because of healthier and more satisfied employees. For example, in a study on healthy building investments, Muldavin et al. (2017) discuss several case studies where optimizations in the work environment in terms of improved IEQ and office layout led to increased cognitive performance and employee productivity. As a result, an increase in the company's overall performance was observed.

Thus, literature does provide insights in potential organizational value that can be derived from an improved mental state. However, such studies are often limited to insights in productivity or financial benefits for an organization (Ipsen et al., 2020; Lindholm & Leväinen, 2006) whereas, the field of performance measurement concerns a far broader understanding of this concept that goes beyond employee productivity and turnover. Renowned performance measurement systems incorporate both financial and strategic indicators and focus on short-term as well as and long-term horizons (Silvi et al., 2015). Additionally, despite the large body of literature on the relationship between the physical work environment and mental health+ concepts, research only tends to focus on a very specific aspect of this relation, discussing the effects of a certain element of the physical workspace on one or several mental health+ concepts. A holistic overview that provides insights in the potential organizational value that can be derived from optimizations of the physical work environment on improving employee mental health+ (Figure 1) is currently missing (Appel-Meulenbroek et al., 2018; Riba Sagar et al., 2019; Watson, 2018).

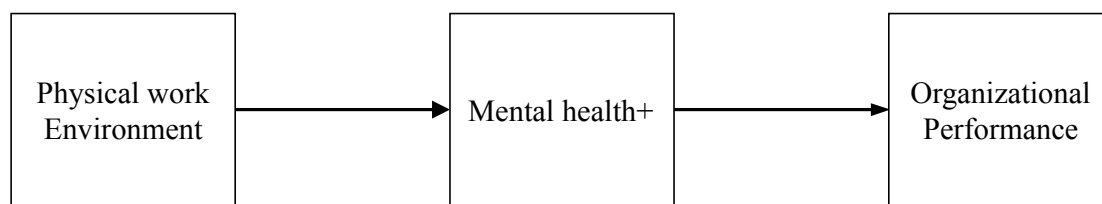


Figure 1: Abstracted relation between physical work environment, mental health+ and organizational performance

1.2 Research Aim

The aim of this study is to provide insights in the potential added value of workplace interventions for office organizations, based on the effects of changes in the physical work environment regarding improved employee mental health+. These insights are presented by means of a business case tool.

In general, a business case is used to inform decision makers on potential outcomes and consequences of choosing certain alternatives (Kepczynski et al., 2018) by linking financial and non-financial gains to certain events or activities that can be undertaken (Quanbeck et al., 2012). In the current research, a business case could provide insights in the potential organizational value that results from changes in the physical work environment that positively affect employee mental health+. The outcomes of this study can then be used to guide the decision-making process in choosing certain workspace interventions by identifying which of these interventions are expected to be most beneficial to an organization and its employees.

The main research question is formulated as:

How can changes in the physical work environment, that could positively affect employee mental health+, be collated into a business case tool, showing the potential added value of workplace design alternatives to office organizations?

To answer this question, the following sub questions are defined:

1. *Which KPIs can be used to indicate organizational performance and added value for office organizations?*
2. *How do the mental health+ concepts relate to these KPIs?*
3. *How does the physical work environment relate to the mental health+ concepts?*
4. *How can the above-mentioned potential relationships be translated into a business case tool?*

1.3 Relevance

The relevance of this study can be observed from various perspectives. The study is particularly relevant in the light of the development of new workplace strategies regarding the post-COVID-19 workspace in providing safe and healthy work environments to employees of office organizations.

From an academic point of view, literature stresses the need for clarification of the link between the workspace and its occupant's mental health (Clements-Croome, 2018; Watson, 2018). The current research responds to this need by contributing to a more advanced understanding of the relationship between the physical work environment and an individual's mental health+, by collating existing knowledge on this relationship into a holistic model. Moreover, it provides first insights into the potential organizational benefits that can be derived from optimizations in the physical workplace via improved mental health+. In a study on the effects of the workspace (light, noise, air) and well-being on productivity, Wiik (2011) already indicates that various aspects of the physical work environment relate to an employee's mental state and organizational performance. Building on these results, Wiik (2011) also states that a holistic approach can further explore the relations between these factors, which is the aim of the current study.

In addition, the outcomes of this study provide relevant information to the field of corporate real estate management. As indicated by Lindholm & Leväinen (2006) and Singer et al. (2007), the majority of CRE decisions today were solely based on short-term reductions in costs and optimizations in efficiency. Such a narrow focus could however have long-term consequences, as the approach of basing strategies on efficiency reasons only may result in employees becoming dissatisfied with the working environment (Gibler & Lindholm, 2012). The business case tool developed in this research indicates the potential consequences of certain workspace interventions, which can be used to support the development of CRE strategies as well as in the decision-making process in selecting or prioritizing interventions. Additionally, as the lack of insights into the organizational benefits that result from workplace interventions withholds employers to invest in the physical work environment, gaining more insights in these benefits might encourage organizations to invest in employee mental health+ by optimizing the physical workspace. As Appel-Meulenbroek et al. (2018, p. 77) also put it: *“real estate and management academics could study how proven benefits can be expressed in money and then perform cost-benefit studies, as this might be the ultimate way to convince practice of actually spending money on interventions to improve work environments to support their employees.”* Hence, CRE departments can use the outcomes of this study to justify investments in the office environment, by indicating to what extent the implementation of certain measures to support employee mental health+ could be beneficial to an organization.

Finally, the relevance of this study can be defined from a societal point of view. Considering the increasing number of health issues in the workplace as described in section 1.1, society will benefit from optimizations in the physical workspace that support an individual's mental state. Additionally, increased health among employees will reduce overall healthcare costs. Furthermore, when organizations start investing in measures to support employee health in the workplace, employees are provided with a sense of appreciation and recognition, which positively contributes to individuals' well-being and satisfaction with their occupation (Larsen, 1993; Ward, 2018).

1.4 Outline

This paragraph explains the outline of the thesis, visualized in Figure 2. After the introduction in the current chapter, the literature review in Chapter 2 elaborates on defining organizational performance and selecting a performance measurement tool that is used in the identification of performance KPIs. Furthermore, the literature review aims to establish a link between mental health+ and KPIs used to indicate organizational performance. The literature review concludes with a model visualizing the relations that are found. Next, Chapter 3 introduces the methods used to execute the research and to answer sub questions 3 and 4. The fourth chapter entails the results of the systematic review, which is used to define the links between the physical work environment and mental health+. These links are

visualized in a model after discussion of the results. Additionally, Chapter 4 discusses the development of the business case tool which collates the relations found in the literature review and systematic review into a model showing the potential added value for office organizations that results from improvements in mental health+ and the physical work environment. Chapter 5 discusses the results of the study regarding the implications for theory and the limitations. The thesis ends with a conclusion in which an answer to the research question and sub questions is provided. This chapter also mentions recommendations for future research and discusses the practical implications of the results.

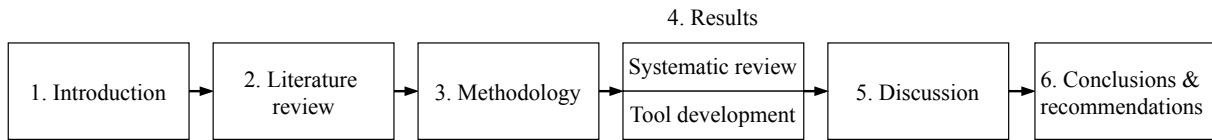


Figure 2: Visualization of thesis outline

2. Literature Review

The physical work environment is characterized by (1) light & daylight, (2) indoor air quality & ventilation, (3) noise, acoustics, & privacy, (4) temperature & thermal comfort, (5) office layout & design, (6) biophilia, greenery, views & plants and (7) look, feel & color (Bergefurt et al., 2021) and is expected to impose effects on mental health+ concepts and organizational performance (Figure 1). The aim of the literature review is to provide insights in how the mental health+ concepts affected by the physical work environment relate to organizational performance by answering sub questions one “*which KPIs can be used to indicate organizational performance and added value for office organizations?*” and two “*how do the mental health+ concepts relate to these KPIs?*”.

The literature review consists of three sections. Section one elaborates on defining and measuring organizational performance and discusses various performance measurement tools by analyzing scientific literature on performance measurement. Resulting from this analysis, one performance measurement tool is chosen to function as a basis in the identification of key performance indicators in section two. This second section reviews literature on the possible relationships between mental health+ concepts and key performance indicators used to measure organizational performance. The final section draws a conclusion based on the findings and visualizes the relevant relations in a model.

2.1 Organizational Performance

Organizational performance is “*a compound concept that reflects the function and outputs of an organization, from its profitability and productivity to its competitive advantage.*” (Ipsen et al., 2020, p. 1). However, it is challenging to provide brief and comprehensive insights in an organization’s performance, since this contains a balanced combination of various financial and strategic elements on both short-term and long-term horizons (Kaplan & Norton, 1992; Lindholm & Leväinen, 2006). This especially applies when measuring the contribution of corporate real estate to an organization’s overall performance, considering that the outputs of CREM usually support internal objectives and strategies that enhance an organization’s success (Lindholm & Leväinen, 2006; Lindholm & Nenonen, 2006). Only focusing on the traditional return on investment of CRE would thus provide limited insights in its contribution to performance in general, as the strategic output is not considered. Hence, measuring performance requires a multidisciplinary approach (Tagliaro & Szívós, 2020) that considers the coherence of different variables that together define company performance. This approach should thus combine financial and strategic measures from various time windows (Lindholm & Leväinen, 2006; Silvi et al., 2015) and provide insights from different viewpoints or perspectives within an organization (Kaplan & Norton, 1996b).

Different performance measurement methods are applied in different fields, ranging from instruments with a financial focus to more complex tools that integrate various components of company performance. Commonly used approaches with a financial focus (e.g. cost benefit analysis and ROI-tools) are often applied to model the output of certain business strategies and scenarios (Hunt, 1984; Muldavin et al., 2017). However, as indicated, such tools are not particularly useful when considering all aspects of organizational performance, because several elements (e.g., quality, satisfaction) cannot easily be expressed in monetary terms (Tagliaro & Szívós, 2020). Regarding instruments that provide a more comprehensive overview of company performance, a distinction can be made between tactical and strategic tools (Table 1) (Lindholm & Leväinen, 2006; Tagliaro & Szívós, 2020).

Table 1: Tactical and strategic tools (Lindholm & Nenonen, 2006; Tagliaro & Szívós, 2020)

	Tactical tools	Strategic tools
Purpose	Analyzing current situations	Managing processes and outcomes
Level	Internal use: processes, projects	Strategic level
Spectrum	Comprehensive	Strategic/holistic
Timing	As-needed basis	Continuous monitoring

Tactical tools

Tactical performance measurement methods are used to evaluate current situations or the development of certain areas (Tagliaro & Szívós, 2020). These tools are usually applied to internal processes and projects and are implemented on an as-needed basis (Lindholm & Nenonen, 2006). An often-used tactical performance measurement method is Post-Occupancy Evaluation (POE). POE examines the effectiveness of buildings for their users regarding occupant satisfaction and functional fit within an office (Zimmerman & Martin, 2001) once occupied by users (Meir et al., 2019). POE can incorporate various elements of the workspace (e.g., health, safety, comfort, quality) and is set up to specifically fit the requirements of the user (Meir et al., 2019; Zimmerman & Martin, 2001). However, the approach of tactical tools such as POE is limited to a real estate perspective (Tagliaro & Szívós, 2020) and does not consider impacts on broader (e.g. organizational) levels (Lindholm & Leväinen, 2006), making the output less applicable to the core business of an organization (Lindholm & Nenonen, 2006). On top of that, different stakeholders have different interests which leads to conflicting outcomes of the assessment. For example, as indicated by Zimmerman and Martin (2001), financial departments generally aim for efficiency and cost reductions, whereas building users focus on optimizing comfort, quality, and functionality. Assessing the impact of certain interventions from different stakeholder perspectives within an organization results in highly complicated outcomes of the evaluation, making it challenging to apply the findings to an organization's overall functioning. Bearing in mind that tactical performance measurement tools are limited to the real estate perspective and thus do not provide insights into the impacts on other processes within an organization, it is challenging to gain an understanding of the effects of workplace interventions on overall organizational performance. Moreover, evaluation tools such as POE are periodic assessments conducted after the implementation of a certain intervention, whereas performance measurement methods with a holistic scope are based on continuous monitoring of processes (Tagliaro & Szívós, 2020).

Strategic tools

Strategic tools are used to manage processes and outcomes, by connecting the output of measurement systems to corporate strategies (Tagliaro & Szívós, 2020). To better define the purpose of strategic tools, it is important to recognize the difference between measuring and managing performance. When *measuring* performance, the progress in obtaining objectives is assessed. Performance *management* uses the information that results from performance measurement to optimize strategies and processes on an organizational level (Amaratunga & Baldry, 2003). In comparison to tactical tools that evaluate internal interventions or projects on an as-needed basis, strategic tools continuously monitor organizational processes with a holistic spectrum.

Given the scope of the current research, it is important to use a tool that considers all layers of an organization in measuring performance. Hence, a strategic tool with a holistic spectrum is preferred over a tactical one that is limited to a single process or project. Moreover, as effects and indicators can change over time, it is required to continuously monitor progress within processes on both short and long-term horizons rather than relying on periodic assessments only. Next, as the focus is on gaining insights in the added value for office organizations, the chosen method should be applicable to a knowledge worker context rather than to companies whose core business concerns the delivery of a certain product or service. Furthermore, a major pitfall in selecting an applicable performance measurement method is the absence of the incorporation of measures related to CREM. As Lindholm and Nenonen (2006, p. 110) put it: *“the main problem with the strategic performance measurement seems to be the lack of comprehensive CREM measures, which could provide the overall picture of the CREM processes and outcomes”*. Naturally, as the current study focusses on the effects on organizational performance that result from changes in the physical work environment, the selected method should thus be applicable to the field of CREM. Finally, literature emphasizes that corporate objectives are very specific and greatly differ between organizations (Lindholm & Nenonen, 2006). There is no overall indication of ‘good’ performance that can be applied to business in general (Lindholm & Leväinen, 2006). The selected method should thus offer a degree of flexibility that enables its users to align the contents to the vision and strategy of a certain organization rather than providing a static overview of performance measures in general.

Regarding strategic tools, literature mentions several methods that are commonly applied in the field of performance measurement: the Performance Pyramid, Navigator, Intangible Assets Monitor and the Balanced Scorecard (Ali et al., 2015; Bontis, 2000; Lindholm & Nenonen, 2006; Rasila et al., 2010). The essence of each tool is described in the following paragraphs, together with a discussion of the suitability of the tool regarding the scope of the current research (Table 2).

Table 2: Strategic performance measurement systems

	Strategic/holistic spectrum	Continuous monitoring	Short & long-term horizons	Knowledge worker context	Comprehensive CREM measures	Flexible
Performance Pyramid	✓	✓	✓			
Navigator	✓		✓	✓		✓
Intangible Assets Monitor	✓	✓	✓	✓		✓
Balanced Scorecard	✓	✓	✓	✓	✓	✓

Performance Pyramid

The performance pyramid is derived from the idea that managing performance should not be limited to measuring financial indicators only, but also consider strategic elements (Lynch & Cross, 1991). The method is based on the perception of an organization existing of multiple layers, each with their own focus and purpose. The performance pyramid maps out these layers and their objectives and links them to overall organizational performance, where all layers support each other in achieving organizational success (Ali et al., 2015; Rasila et al., 2010). Regarding overall organizational performance, the performance pyramid distinguishes three driving forces. As stated by ACCA (2020), the first focus is on ensuring customer satisfaction with the products delivered by an organization. Next, insights should be provided in the flexibility required to meet customer standards. Finally, in terms of productivity, it is required to reduce costs and process times as much as possible. These three driving forces are monitored by indicators related to waste disposal, delivery times and quality and efficiency of process cycles (ACCA, 2020).

Comparing the performance pyramid to the requirements defined for the selection of a suitable method to identify KPIs for organizational performance (Table 2), the first three requirements are met. The approach indeed has a strategic focus and continuously monitors information. Furthermore, information resulting from monitoring the indicators is used to gain insights in direct effects on three perspectives regarding productivity, flexibility, and, in turn, customer satisfaction, indicating a focus on both short and long-term horizons. However, as the focus is on efficiency and effectiveness of production processes, the tool is not directly applicable to a knowledge worker context. Moreover, the tool does not mention the incorporation of CREM. Finally, as the indicators that are used in the tool are fixed and limited to the three main perspectives, a high level of flexibility cannot be achieved.

Navigator

The Navigator tool is specifically designed to measure performance for knowledge assets (Bontis, 2000; Lindholm & Nenonen, 2006). According to Bontis (2000), the tool applies a holistic scope with five focus areas: financial, customer, process renewal and development and human capital, which should provide insights in an organization's financial as well as strategic capital. Each focus area is represented by a set of measurable metrics. Regarding the financial office, measures relate to revenues per employee or profits that result from new business operations. Next, the customer focus aims at measuring the number of customers, ratio of sales closed and customer retention. Thirdly, the process focus entails the

measurement of metrics related to internal processes such as process time and ICT facilities. Within renewal and development, the focus is on the number of satisfied employees, training expenses and patent ages. Finally, the human focus measures the percentage of advanced degrees within the workforce and staff turnover (Bontis, 2000). Performance of these measures is tracked, and information is combined into a balance sheet that provides insights in an organization's capital.

The navigator tool is considered useful in its approach to measure performance with a holistic perspective and allows its user to gain insights in an organization's overall functioning (Bontis, 2000; Edvinsson & Malone, 1997). Furthermore, Edvinsson and Malone (1997) argue that the model can be applied to various industries due to the possibility to select indicators that specifically relate to a certain business sector. However, regarding the requirements in Table 2, criticism on the tool concerns its limited capability in providing insights in the continuous flows within an organization, since the balance sheet that results from the tool only offers a snapshot of an organization's performance in time (Roos et al., 1997). Furthermore, no information is provided on the usefulness of the tool within the field of CREM, indicating a suboptimal fit with the current study.

Intangible Assets Monitor

The intangible assets monitor, developed by Sveiby (1997) provides a model that allows its user to gain insights in an organization's performance by tracking intangible assets (Bontis, 2000). Besides providing information to external stakeholders and shareholders, another purpose of the model is to track the internal processes within the organization. As stated by Sveiby (1997, p. 77): "*The management needs to know as much as possible about the company, so that it can monitor progress and take corrective action when warning signs appear*". The output of the monitor supports the development of the corporate strategy. The intangible assets monitor focusses on the external (customer and supplier relations, brands) and internal structures (processes, management) of an organization together with individual competence (education and experience of staff). Next, management should identify a set of indicators for each of these perspectives that relate to an organization's growth and renewal, efficiency and stability (Sveiby, 1997). A sample of the indicators that can be selected is provided in Figure 3:

	External structure	Internal structure	Competence of people
Growth and renewal	Customer profitability Sales growth	Internal investments Company culture	Years of experience Education level
Efficiency	Customer satisfaction Sales per customer	Proportion of sales per employee	Value-added per professional
Stability	Customer retention Customer loyalty	Staff turnover Age of the organization	Average age seniority

Figure 3: Sample measures in intangible assets monitor (Bontis, 2000; Sveiby, 1997)

Looking at the requirements in Table 2, the intangible assets monitor provides insights in an organization's functioning with a holistic spectrum. Furthermore, indicators are continuously monitored, and information is used for immediate actions in the short term or to support the development of strategies with a long-term focus. In addition, the method is particularly useful for measuring performance in knowledge worker firms, due to the major focus on intangible assets (Lindholm & Nenonen, 2006) and, as managers have personal control over the identification of indicators used in the model, the framework can be set up to specifically align to the corporate strategy. However, no information was found on the application of the model in the field of CREM.

Balanced Scorecard

In interviews with 26 corporate real estate executives, Lindholm & Leväinen (2006) found that the most popular strategic performance measurement tool within the field of corporate real estate is the Balanced Scorecard (BSC). The BSC is considered to provide a useful framework for measuring company performance (Tagliaro & Szívós, 2020) and is internationally recognized and successfully applied within multiple professional disciplines (Amaratunga et al., 2000) among which the field of corporate real estate and facility management (Rasila et al., 2010; van der Voordt, 2004). The BSC uses a holistic approach in measuring company performance (Barnabè & Busco, 2012; Kaplan & Norton, 1992; O'Neill, 2007) by allowing its user to continuously monitor performance based on four different perspectives: the *client* perspective, *internal business processes* perspective, *learning and growth* perspective and the *financial* perspective (Figure 4). Each perspective contains a set of critical key performance indicators (KPIs) that should be monitored in order to provide insights in an organization's overall functioning (Kaplan & Norton, 1996b). Using these different perspectives, the BSC is able to provide a more comprehensive overview of CREM measures, as opposed to other strategic tools (Lindholm & Nenonen, 2006). Furthermore, the popularity of the BSC within CREM can be explained since a vast majority of organizations is already familiar with the approach as it is generally applied within the core business of these organizations (Lindholm & Leväinen, 2006).

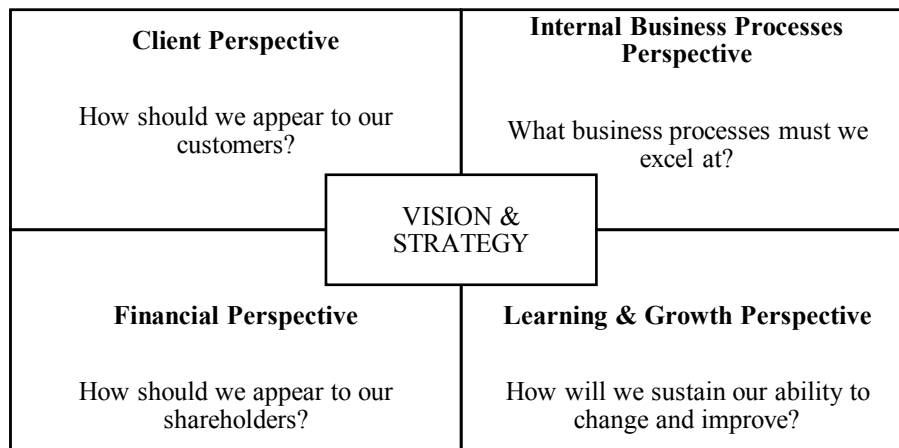


Figure 4: Four perspectives of the Balanced Scorecard (Kaplan & Norton, 1992)

The *client* perspective discusses how the organization is seen by its customers and focusses on general customer values, which are found to be related to time, quality, performance and service, and costs (Kaplan & Norton, 1992; Lawrie et al., 2004). In other words, this perspective focusses on meeting the customer's expectation in terms of qualitative and quantitative performance (Hladchenko, 2015). Optimization of these objectives would thus lead to higher levels of customer satisfaction. As the customer perspective represents the sector that will deliver revenue to the organization, customer objectives are crucial to monitor. Next, the *internal business process* perspective considers which internal processes are vital in meeting the customer's expectations. As stated by Kaplan & Norton (1992, p. 10): "The internal measures for the balanced scorecard should stem from the business processes that have the greatest impact on customer satisfaction." As the main customer values are captured in terms of time, quality, performance and service, and costs, the objectives for the internal processes should focus on the internal aspects that are essential for optimization of these values (e.g. efficiency and quality of processes) (Hladchenko, 2015). The *learning and growth* perspective represents a basis that enables the objectives from the other perspectives to be achieved (Kaplan & Norton, 1996b; Lindholm & Leväinen, 2006). The aspects in the learning and growth perspective set the optimal conditions for the objectives from other perspectives by asking which elements of organizational and staff development are vital to ensure the success of the organization (Nickel, 2011). Optimizing the indicators from all three perspectives should be visible in the financial performance of an organization (e.g. cost reductions and profits), which focusses on the quantitative results that should be achieved (Hladchenko, 2015) and is represented in the *financial* perspective (Kaplan & Norton, 1996b).

The BSC framework has evolved with the development of strategic performance measurement within organizations (Andersen et al., 2015). In addition to the combination of financial and non-financial performance measures divided over four perspectives, a strategy map was added to support the identification of strategic activities and measures that should be included in the model (second generation BSC) (Andersen et al., 2015). Next, in the third generation model, full management participation in defining the key strategic objectives dealt with the unclarities on who should be responsible for the identification of these particular objectives (Andersen et al., 2015; Lawrie et al., 2004). In other words, identification of the strategic objectives that should be monitored requires participation of the full management, as all fields of an organization (HR, ICT, CREM, etc.) should be considered (Lawrie et al., 2004; Lindholm & Nenonen, 2006).

In comparison to the other performance measurement tools, the BSC meets all requirements defined for the selection of a suitable method. Similar to the other methods, the BSC has a holistic spectrum and is applicable to both short and long-term horizons. Furthermore, as users personally select indicators that are essential to an organization, it provides high levels of flexibility in comparison to tools that offer a generic overview of measures. This flexibility allows the tool to be applicable to various business sectors among which knowledge firms. Finally, there are various records indicating a successful application of the tool within the field of CREM, which separates the BSC from the other methods.

2.2 Relations Between Mental Health+ and Organizational Performance

Employee's mental health is central to human behavior in the workplace and inseparably linked to organizational performance, as a company's overall performance depends on how effectively its employees function (Ipsen et al., 2020). As mentioned in Chapter 1, the concept of mental health+ is introduced by Bergefurt et al. (2021) and is defined as a combination of ten mental health concepts, specifically related to the office work environment context: *stress, sleep quality, fatigue, mood, concentration, perceived productivity, engagement, burnout, depression, and well-being*.

Using the BSC in the identification of KPIs

The aim of this second section of the literature review is to identify how mental health+ relates to organizational performance, and which KPIs are used to indicate organizational performance. As indicated in the first section, the BSC is used in the identification of these KPIs. Building on the BSC approach, Van der Voordt (2004) introduces an adaptation of the framework that specifically focusses on measuring performance in various workplace environments. According to Tagliaro and Szívós (2020, p. 7), this adaptation “*is a suitable platform to combine the positive and negative impacts of workplace decisions from a client, internal business process, and learning and growth perspective and link them to more traditional financial indicators.*” In other words, the BSC adaptation by Van der Voordt (2004) can be used to gain insights in the potential impacts of workplace interventions on company performance by monitoring indicators related to the four perspectives identified in the original BSC model. However, this model cannot be directly applied to the current research, as the model focusses on the risks and profits that result from changes in the work environment rather than affected mental health+ concepts. Furthermore, Van der Voordt's framework includes various indicators that are similar to several mental health+ concepts that are distinguished in the present study. Implementation of this model would therefore result in circular reasoning.

Instead, to identify the potential organizational effects from affected mental health+ concepts, literature is sought that discusses one or several mental health+ concepts in relation to either the four perspectives of performance measurement (client, internal business processes, learning and growth and financial) or corresponding KPIs. Van der Voordt's model (2004) will then be used to check whether this framework supports the choice for the KPIs that result from the literature review.

Search strategy

Reviewed papers were retrieved from databases Scopus and Google Scholar. Considering that the aim is to gain insights in the relationship between mental health+ and organizational performance KPIs, articles were first selected based on combinations of terms referring to mental health+ and organizational

performance in the title, abstract or keywords (Figure 5). Since the BSC framework is used to define a set of KPIs that represent the different aspects of an organization's performance, the perspectives within the BSC are also used in the search terms. Next, studies in which the research question did not focus on the relationship between mental health+ concepts and KPIs were excluded from the set of articles. Moreover, as mental health+ concepts are often interpreted differently, papers were only included in the analysis when their definition of these mental health+ concepts was similar to the ones used in the current research. This resulted in a number of 38 studies that were included in the analysis.

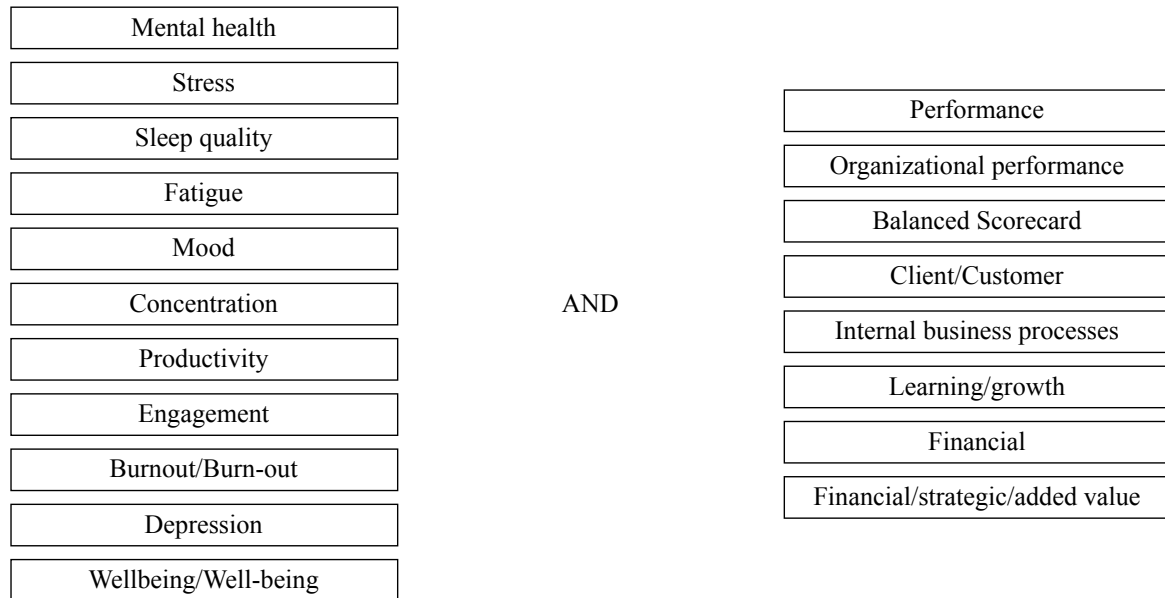


Figure 5: Search strategy

Table 3 presents an overview of the final set of articles included in the analysis, together with the KPIs discussed in these articles. The KPIs are already categorized under the four perspectives of organizational performance according to the BSC. A definition of these KPIs is provided in Table 4. The upcoming paragraphs each discuss a separate mental health+ concept and its relation to KPIs, according to the articles in Table 3.

Table 4: Definitions of KPIs

Client	
Customer satisfaction	Degree of satisfaction with delivered products and services (Bakker et al., 2008; West & Dawson, 2012).
Internal Business Processes	
Absenteeism	The practice of being absent from work (Barnes & Watson, 2019; Cooper & Dewe, 2008).
Communication	Interaction between colleagues with regard to organizational processes (Maslach et al., 2001; Swanson et al., 2011).
Job satisfaction	Degree of employee satisfaction with their current occupation (Ipsen et al., 2020; Page & Vella-Brodrick, 2009).
Performance	Efficiency and quality of the output delivered by an employee (Maslach et al., 2001; Miner & Glomb, 2010; Obuobisa-Darko, 2020).
Presenteeism	The productivity or performance lost when employees come to work while being ill and perform below standards (Cooper & Dewe, 2008; Schultz & Edington, 2007).
Staff turnover	The rate or number of employees that leave the organization within a certain time period (Maslach et al., 2001; Page & Vella-Brodrick, 2009).
Learning & Growth	
Employee innovation	Behavior with regard to proactive attitude, initiative and contribution to new ideas and services (Ipsen et al., 2020; West & Dawson, 2012).
Flexibility	The ability to quickly respond to and switch between tasks (De Menezes & Kelliher, 2017; Miner & Glomb, 2010).
Financial	
Turnover	Total revenue generated in a certain period of time (Caldwell et al., 2019; Kaplan & Norton, 1996a).

Stress

Stress, in particular job-stress, is described as the arousal caused by physical (e.g. environmental) or psychosocial (e.g. organizational) stressors at work (Bluyssen et al., 2011; Shafaghat et al., 2014; Vischer, 2007), and can be experienced as positive (eustress) or negative (distress) (Selye, 1956). Increasing performance standards and therewith creating a challenging environment up to a certain extent would result in employees experiencing healthy stress levels that enhance *performance* and decreases *presenteeism* (Hargrove et al., 2015). However, when performances standards are raised and work pressure keeps increasing, employees will experience negative feelings of stress, which is associated with low *job satisfaction* (Chang & Lu, 2007; De Menezes & Kelliher, 2017), decreased *performance* (De Menezes & Kelliher, 2017; Kottwitz et al., 2019) and increasing levels of *presenteeism* (Cooper & Dewe, 2008), indicating a curvilinear relation between stress and *performance* and *presenteeism*. Consequences of these changes are found to result in more frequent *absenteeism* (Chang & Lu, 2007; De Menezes & Kelliher, 2017) and, in the long term, higher levels of *staff turnover* (Page & Vella-Brodrick, 2009).

Sleep quality

Quality of sleep is determined by three main aspects; difficulties initiating sleep, difficulties maintaining sleep and non-restorative sleep (the feeling that sleep has been insufficiently refreshing) (Knudsen et al., 2007). Reduced sleep quality overnight results in higher levels of tiredness on the job the next day and was found to affect organizational outcomes. For example, insufficient sleep was found to decrease workplace joy and therewith *job satisfaction* (Barnes & Watson, 2019), which, on the long term, led to higher rates of *absenteeism* (Barnes & Watson, 2019; Swanson et al., 2011). Furthermore, employees that reported insufficient sleep had less energy and shorter attention spans, which resulted in reductions in *performance* (Barnes & Watson, 2019; Caldwell et al., 2019; Kottwitz et al., 2019; Schilpzand et al., 2018; Swanson et al., 2011), *innovation* (Barnes & Watson, 2019; Schilpzand et al., 2018; Swanson et al., 2011) and increased *presenteeism* (Barnes, 2019; Swanson, 2011). On top of that, Swanson et al. (2011) observed that employees who experienced worse sleep were more likely to avoid interaction with colleagues, which negatively affected *communication* in the workspace.

Fatigue

Feelings of fatigue among employees depend on the time awake, time of the day, workload and an individual's health and lifestyle. Furthermore, poor sleep quality during nighttime was found to be a major predictor of daytime fatigue (Caldwell et al., 2019). Caldwell et al. (2019) found that employees experiencing an increase in feelings of fatigue were less alert and active, which negatively affected *performance*, *flexibility*, *innovation*, and *job satisfaction*. Similar results were obtained in other studies, where reductions in *performance* (Barker & Nussbaum, 2011; Boksem & Tops, 2008; Cropanzano et al., 2003; Roelofsens, 2002; Szalma & Harris, 2008), *innovation* (Chung et al., 2017) and *job satisfaction* (Cropanzano et al., 2003) were reported as well. In the long term, these negative effects resulted in more frequent *absenteeism* (Caldwell et al., 2019), higher rates of *staff turnover* (Cropanzano et al., 2003) and reductions in financial *turnover* (Caldwell et al., 2019; Cropanzano et al., 2003). Besides, negative effects on *communication* were observed as, similar to poor sleep quality, employees with increased feelings of fatigue were more likely to avoid social interaction with co-workers (Boksem & Tops, 2008; Caldwell et al., 2019).

Mood

Mood, which is to a certain extent also predicted by an individual's sleep quality (Barnes & Watson, 2019), is a major contributor to the way information is received and processed (Lesiuk, 2010; Miner & Glomb, 2010). In a study on behavior within and between various customer service-teams, Miner & Glomb (2010) found that, compared to co-workers with a negative mood, employees with a more positive mood showed higher levels of *flexibility* and were faster when providing service to customers. It is likely that *performance* is affected by an employee's mood, as negative feelings cannot easily be ignored, which leads to less attention and thus less cognitive capacity available for processing tasks (Barnes & Watson, 2019; Ipsen et al., 2020; Lesiuk, 2010; Szalma & Harris, 2008). Next, the theory of emotional contagion (Forgas, 1995), suggests that positive or negative behavior is 'copied' by others. In a customer-facing role, it can thus be expected that an employee's mood affects a customer experience and therewith influences *customer satisfaction*, which was confirmed in various studies that also reported increased *job satisfaction* among employees (Barnes & Watson, 2019; Ipsen et al., 2020).

Concentration

Various job activities require an employee to fully focus on a task without being distracted. This requires an optimal work environment as certain aspects of the workspace can easily cause disruptions in an employee's ability to concentrate (Haghighat & Donnini, 1999; Menzies et al., 1997; Seddigh et al., 2015). When concentration levels are reduced, employees are no longer able to efficiently and effectively perform tasks (McDonald & Siegall, 1992), which results in reductions in overall *performance* (Kahya, 2007; Kottwitz et al., 2019; Szalma & Harris, 2008; van der Voordt, 2016) and a decrease in *turnover* in the long term (Kaplan & Norton, 1996a; Obuobisa-Darko, 2020).

Productivity

Perceived productivity (i.e. the perception of an individual's contribution to the overall value an organization is creating (Pershing, 2006), is partially depending on the ability to concentrate while performing job activities. Reductions in the ability to concentrate results in less output delivered by an employee and therewith a lower perception of the amount of work delivered by this individual (Obuobisa-Darko, 2020). According to Wiik (2011, p. 329), perceived productivity is an appropriate measure for determining overall *performance* as "*individuals are likely to work in accordance with their own feelings, regardless of what behavioral or psychological measures indicate.*" Other studies too, established a link between subjective productivity and *performance* (Baird, 2017; Obuobisa-Darko, 2020; van der Voordt, 2016). Similar to concentration, productivity is also positively correlated to *turnover* (Kaplan & Norton, 1996a; Obuobisa-Darko, 2020).

Engagement

Highly engaged employees can be characterized as motivated, enthusiastic and dedicated to their work (Bhuvanaiah & Raya, 2015; Maslach & Leiter, 2016; West & Dawson, 2012). According to existing literature, improved engagement levels among employees result in improved *performance* (Bakker et al., 2008; Bhuvanaiah & Raya, 2015; Crabtree, 2013; Maslach & Leiter, 2016; Obuobisa-Darko, 2020;

Powell et al., 2014) and *innovation* (Bhuvanaiah & Raya, 2015; Obuobisa-Darko, 2020). According to Bakker et al. (2008), these effects can be explained by the increased levels of enthusiasm and motivation associated with an engaged employee, which also positively affects *customer satisfaction* (Bakker et al., 2008; Crabtree, 2013; Maslach & Leiter, 2016; Powell et al., 2014; West & Dawson, 2012). Similarly, West & Dawson (2012), indicated that engaged employees are less likely to make mistakes, improving overall *performance*, which results in increased *turnover*. On top of that, Maslach et al. (2001) found that the positive attitudes that were observed with engaged employees were likely to be reflected in the behavior of others, causing the KPIs related to organizational performance to be affected by the entire workforce. Next, higher levels of engagement led to improved *job satisfaction* (Maslach & Leiter, 2016) and, in turn, lower *absenteeism* rates (Crabtree, 2013; Powell et al., 2014) and reductions in *staff turnover* (Crabtree, 2013; Powell et al., 2014).

Burnout

Burnout is a psychological condition caused by emotional and social stressors experienced at the workplace such as the feeling of not being able to contribute to a job and exhaustion caused by high amounts of stress and is often considered as the opposite of engagement (Maslach & Leiter, 2016; West & Dawson, 2012). Being on the opposite side, burnout can be expected to affect similar KPIs as engagement, however, in a negative way. According to the literature, burnout indeed negatively affects *performance* (Burton et al., 2008; Maslach et al., 2001; Salyers et al., 2015; Taris, 2006), *presenteeism* (Burton et al., 2008), *innovation* (Bakker et al., 2000; Maslach et al., 2001; Salyers et al., 2015) and, in turn, *customer satisfaction* (Taris, 2006). Furthermore, an increase in burnout-related issues among the workforce was found to decrease *job satisfaction* (Maslach & Leiter, 2016) and, when focusing on the long term, increase *absenteeism* rates (Burton et al., 2008; Maslach et al., 2001; Maslach & Leiter, 2016; Salyers et al., 2015; West & Dawson, 2012) and *staff turnover* (Maslach et al., 2001; Salyers et al., 2015; West & Dawson, 2012). Finally, similar to engagement, the negative effects of burnout-related symptoms are likely to be reflected by others, creating an even more negative effect within the workforce (Maslach et al., 2001).

Depression

According to Johnson and Indvik (1997), depression is characterized by feelings of helplessness and worthlessness together with anger and sadness for a longer period. Contrary to a burnout, where a loss of energy is experienced at work, depressive feelings are not specifically work-related and can be caused by various other life events. Depression does however negatively affect organizational performance, as indicated by various studies that reported increases in *presenteeism* (Cooper & Dewe, 2008; Schultz & Edington, 2007), decreased *performance* (Chang & Lu, 2007; Schultz & Edington, 2007), low levels of *innovation* (Bakker et al., 2000) and *job satisfaction* (Chang & Lu, 2007) and increased *absenteeism* which, in later stages, resulted in higher levels of *staff turnover* (Chang & Lu, 2007; Cooper & Dewe, 2008; Schultz & Edington, 2007). In a literature review on organizational outcomes of health, Schultz et al. (2007), reported negative effects regarding *presenteeism* and *performance* for employees dealing with depression, as the mental ability to perform tasks and delivered output was significantly lower compared to healthy employees. Furthermore, feelings of diminished enthusiasm and energy affected an employee's proactive attitude, negatively affecting *innovation* (Bakker et al., 2000).

Well-being

Well-being refers to a subjective, self-reported measure that depends on a person's general health and satisfaction with their life and job (Diener et al., 1999). According to this definition, a clear correlation exists between an employee's well-being and *job satisfaction*. This is supported by Page & Vella-Brodrick (2009), who studied employee well-being, *job satisfaction* and employee retention, and found that low levels of well-being are associated with decreased *job satisfaction* and increased levels of *staff turnover*, which was also reported by Powell et al. (2014). In addition, Powell et al. (2014) found a negative correlation between well-being and *absenteeism* rates. Increased well-being, on the other hand, led to improved quality and efficiency of business processes and services, enhancing employee *performance* (Page & Vella-Brodrick, 2009; Robertson et al., 2012).

2.3 Conclusion

The main goal of the literature review was to focus on defining organizational performance and its link to employee mental health+. Two sub questions were formulated to be answered by reviewing scientific literature. Based on the answers of the two sub questions, a model can be defined, visualizing the link between mental health+ and organizational performance. The two sub questions to be answered in the literature review were:

1. Which KPIs can be used to indicate organizational performance and added value for office organizations?
2. How do the elements of mental health+ relate to these KPIs?

Sub question 1 was answered by first looking into literature on performance measurement for office organizations. Here, it was found that the Balanced Scorecard (BSC), introduced by Kaplan and Norton (1992), acts as a useful instrument that allows its user to strategically measure performance within the field of CRE on an organizational level from four different angles: customer perspective, internal business processes perspective, learning and growth perspective and the financial perspective. Next, literature was sought to study the underlying mechanisms between mental health+ and organizational performance KPIs, as formulated in sub question 2. An overview of the relations (positive, negative, or curvilinear) found in the literature is provided in Table 5. It should be noted that the magnitude of the effects depends on various subjective and situational factors as well as individual differences due to which the effect of the relations in the figure cannot be quantified.

Table 5: Relations between mental health+ and KPIs according to literature

	Client Perspective		Internal Business Processes Perspective						Learning & Growth Perspective		Financial Perspective
	Customer satisfaction		Absenteeism	Communication	Job satisfaction	Performance	Presenteeism	Staff turnover	Employee innovation	Flexibility	Turnover
Stress			+		-	-/+	-/+	+			
Sleep quality			-	-	+	+	-		+		
Fatigue			+	-	-	-		+	-	-	-
Mood	+				+	+				+	
Concentration						+					+
Productivity						+					+
Engagement	+		-		+	+		-	+		+
Burnout	-		+		-	-	+	+	-		
Depression			+		-	-	+	+	-		
Well-being			-		+	+		-			

+ *positive*

- *negative*

+/- *curvilinear*

When comparing the set of KPIs identified in the literature review to the BSC adaptation of Van der Voordt (2004) apart from *presenteeism*, all KPIs included in Table 5, are also present in Van der Voordt's framework. The absence of *presenteeism* can be explained as the definition of this indicator is

also captured by the combination of the indicators *productivity*, *quality*, and *time* of business processes in the model of Van der Voordt. In Table 5, *quality* and *time* are combined in the indicator *performance*. In addition, *productivity* is left out to prevent circular reasoning. Van der Voordt's framework also contains various other mental health+ concepts that are not represented in Table 5 for similar reasons. Furthermore, the model of Van der Voordt contains several indicators related to an organization's real estate (e.g., maintenance and electricity costs, return on investment) which are not present in the table, as no relations were found (and are to be expected) between these indicators and mental health+.

According to the literature study, all mental health+ concepts relate to the internal business process perspective, most commonly with respect to *absenteeism*, *job satisfaction* and *performance*. Furthermore, regarding the learning and growth perspective, *employee innovation* was found to be connected to half of the mental health+ concepts. Apart from sleep quality and fatigue, these mental health+ concepts were also found to be major predictors of *customer satisfaction* within the client perspective. Finally, literature discusses the potential effects of fatigue, employee engagement, productivity, and concentration on an organization's financial *turnover*. These potential contributions to possible financial gains are however not elaborated on in greater detail, as it is proven to be challenging to clearly quantify these effects. Apart from financial gains, however, changes in various KPIs that were found while reviewing the literature, can be expected to result in several cost reductions over time. Regarding decreases in staff turnover, for instance, reductions in HR-related costs can be expected as low employee retention would mean less spending on recruiting and educating new employees. Furthermore, reduced absenteeism rates as a result of a decreasing number of employees suffering from burnout or depression related issues will reduce healthcare costs.

Based on the answers to the sub questions derived from the findings in the literature review, a model (Figure 6) was defined, visualizing the mechanisms between mental health+ and organizational performance.

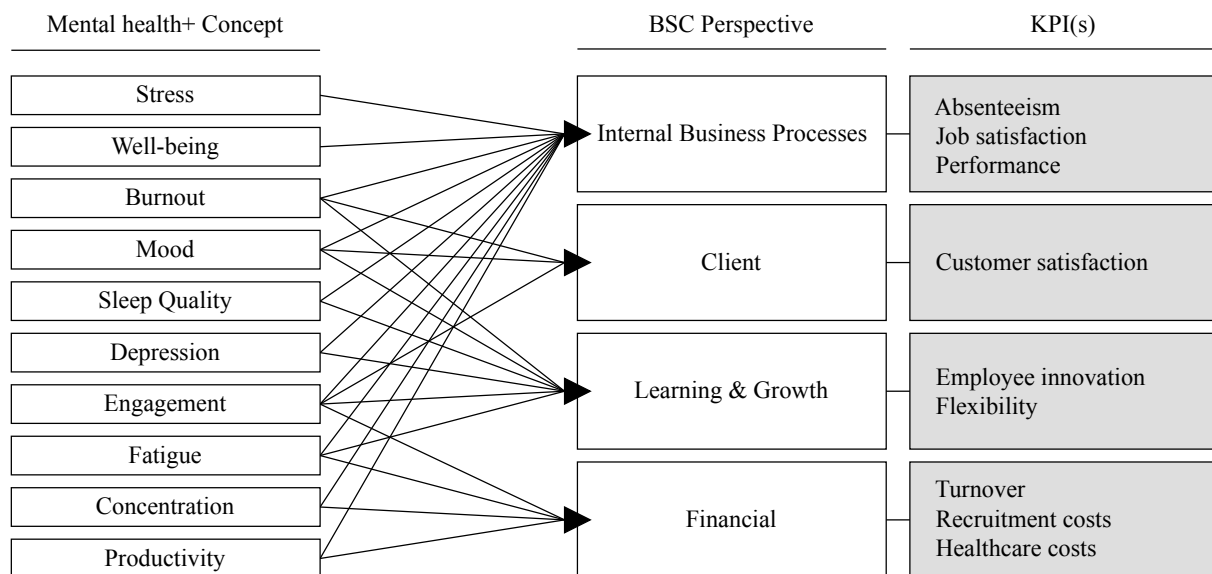


Figure 6: expected links between mental health+ concepts and organizational performance

3. Methodology

This chapter elaborates on the methods used to answer sub questions 3 and 4. The chapter consists of four sections. Section 1 is an introduction to the research methods and explains the background behind the chosen methods. Next, the second section discusses the systematic review, the method selected to gain insights in the relationships between the physical work environment and mental health+. Section 3 focusses on the techniques used to develop the business case in which the results from the literature review (Chapter 2) and systematic review are collated. Finally, section four summarizes the steps that were taken to obtain the results.

3.1 Introduction

The main objective of this research is to develop a tool that enables decision makers to choose between workplace design alternatives, based on the expected impact of the physical work environment on employee mental health+ and potential added value for office organizations. The relationship between mental health+ and performance indicators is studied in the literature review. The remainder of this thesis aims at defining the relationship between the physical work environment and mental health+ and collating the established relationships in a business case model.

To gain insights in how the physical work environment relates to mental health+, first, it is required to define the different elements within each factor. Based on an earlier study by Al Horr et al. (2016), Bergefurt et al. (2021), divide the physical workspace in seven elements: *Office Layout & Office Design; Look, Feel & Color; Biophilia, Greenery, Views & Plants; Temperature & Thermal Comfort; Noise, Acoustics & Privacy; Indoor Air Quality & Ventilation; Light & Daylight*. Additionally, mental health+ is referred to as a combination of mental health+ concepts *productivity, concentration, stress, sleep quality, mood, fatigue, well-being, depression, engagement*, and burnout. To understand how the physical work element affects mental health+, one should review the relations between these components in-depth.

In a systematic scoping review on the relationship between the physical work environment and mental health+, Bergefurt et al. (2021) identified a set of 133 articles that each aim to provide insights in the effects of one or various elements of the physical work environment on mental health+ concepts. By analyzing the results of these studies and putting the findings together, an overview is created of all elements of the physical work environment and how they relate to the mental health+ concepts. This will be done by means of a systematic review.

3.2 Systematic Review

This section discusses the systematic review used to study the relations between the physical work environment and mental health+. First a definition of the systematic review is provided, after which the application is discussed, and a conclusion is drawn regarding the use of this method in the current research.

Defining the systematic review

A systematic review aims to synthesize and summarize existing knowledge (Aromataris & Pearson, 2014) and is argued to be a valuable method in collating existing evidence from a wide range of disciplines (Petticrew, 2001). As indicated by Denyer & Tranfield (2009, p. 671) “*a systematic review is a specific methodology that locates existing studies, selects, and evaluates contributions, analyses and synthesizes data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known.*”

In a report on how to produce a systematic review, Denyer & Tranfield (2009), define four key principles of systematic reviews:

- *Transparency*: the process of each review should be explained in an open and transparent manner that clearly states how the review is conducted. Furthermore, the search strategy that is applied in the selection and analysis of literature included in the review should be set up and reported in such a way that it can be reproduced by others (Greenhalgh, 1997).
- *Inclusivity*: literature is assessed on its relevance related to the aim of the current study. The review includes a wide variety of sources, methods, samples, etc. to ensure a comprehensive understanding of the topic of interest (Pawson, 2006).
- *Explanatory*: the results should focus on synthesis. The reported effects are combined into a generalizable theory by means of an understandable process of drawing conclusions that grasp the combined effects indicated in existing literature (Denyer & Tranfield, 2009).
- *Heuristic*: the systematic review presents tools and guidance to end-users for an effective implementation of the findings (Denyer & Tranfield, 2009).

Application of the systematic review

Within the execution of the systematic review, four main steps can be distinguished: (1) formulating the question, (2) identification of literature, (3) analysis and synthesis and, (4) interpretation of results (Denyer & Tranfield, 2009; Khan et al., 2003).

First, a clearly framed questions should be formulated to establish the focus of the analysis (Denyer & Tranfield, 2009; Khan et al., 2003). In case of the present study, the focus is on the relationship between the physical work environment and mental health+, which is defined by sub question 3: *How does the physical work environment relate to the mental health+ concepts?*

Next, step 2 concerns the identification of studies. Here, the search strategy is defined, which indicates how articles are sought for, evaluated, and selected to be included in the systematic review. As indicated in section 3.1, for the systematic review in the current study, a set of 133 articles is used that was identified in an earlier study by Bergefurt et al. (2021). The second step of the systematic review, identification of studies, is thus executed and extensively reported by Bergefurt et al. (2021). In a scoping review, Bergefurt et al. (2021) identified 133 articles from 1990 to 2020 that each discuss the effects of one or more (components of) elements of the physical work environment on employee mental health+ concepts (Table 6). Studies differed in terms of location, sample size and office and organization type, resulting in a broad overview of components applicable to offices in general.

Table 6: Papers on elements of the physical work environment and mental health+ concepts (Bergefurt et al., 2021)

	Productivity	Concentration	Stress	Sleep quality	Mood	Well-being	Fatigue	Depression	Engagement	Burnout	Nr. of papers
Light and daylight	26	13	11	28	23	6	5	9	3	0	73
Indoor air quality and ventilation	29	14	7	7	4	6	10	2	2	0	49
Noise, acoustics, and privacy	28	16	11	7	5	10	5	4	4	1	49
Temperature and thermal comfort	31	12	4	9	4	5	7	3	2	0	48
Office layout and design	24	7	6	2	1	5	0	3	4	2	34
Biophilia, greenery, views, and plants	12	6	10	3	3	6	1	4	3	0	27
Look, feel and color	7	1	2	0	3	2	1	0	0	0	12
Nr. of papers	56	35	33	33	27	27	17	13	7	3	

Step 3 entails the analysis and synthesis of evidence on the subject. Here, the contents of papers are analyzed and summarized in a structured manner. As mentioned before, the systematic review aims to

gain insights in the relationship between the physical work environment and mental health+. To analyze the findings from the set of 133 articles, the following strategy was used. First, for each article, it was defined which elements of the physical work environment are studied regarding their effects on mental health+ concepts. Within the articles, each workspace element is defined as a combination of one or more measurable components, for example, *room temperature (°C)* and *relative humidity (%)* within *Temperature & Thermal Comfort*. Per element, the associated components were reported in an overview. Next, for each of these measurable components, their effects on mental health+ in terms of affected mental health+ concepts were reported (positive, negative, curvilinear, no effect). Various studies also reported percentages of the effects that were measured (e.g., 3% increase in productivity), which were included in the overview as well. Additionally, based on the findings presented in literature, for each component an optimal, acceptable, and insufficient value was defined with respect to their effects on mental health+ concepts, which too were included in the overview.

Finally, the findings that result from step 3 are interpreted in the fourth step, which uses the observations from studies to draw conclusions. Here, results from the articles are combined into a comprehensive overview on how the physical work environment relates to mental health+. To summarize (Figure 7), the physical work environment consists of seven elements, each represented by a set of measurable components. For each component, an optimal, acceptable, and insufficient value can be defined based on how they affect mental health+ components. In turn, considering the results from the literature review (Chapter 2), the mental health+ concepts affect organizational performance indicators.

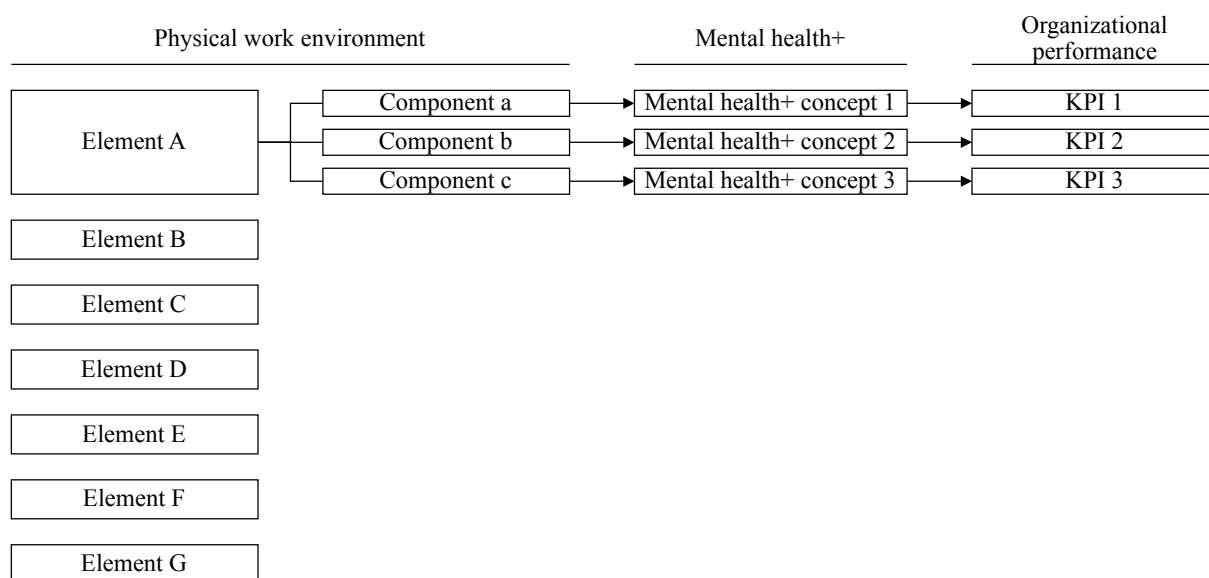


Figure 7: Division of physical work environment elements and components related to mental health+ concepts and organizational performance.

Conclusion

Comparing the method applied in the current study to the principles of a systematic review, it can be stated that the applied method meets the requirements. In terms of *transparency*, both the process of selecting relevant literature (Bergefurt et al., 2021) and analyzing and synthesizing results are explained in a transparent manner, allowing others to reproduce this process. Next, regarding *inclusivity*, literature analyzed in the systematic review originates from a wide range of disciplines with different characteristics (e.g., sample size, location, type of experiment). The results of the systematic review are combined into an overview that indicates the relationships between the physical work environment and mental health+ in general which is in line with the *explanatory* principle. Finally, regarding the *heuristic* aspect of the systematic review, results are collated into a business case tool that allows users to implement the findings. The setup of the tool is explained in the next paragraph.

3.3 Business Case Tool

This third section of the methodology explains and reviews the development of the business case tool which collates the findings from both the literature and systematic review into a holistic model.

The purpose of the business case model is to provide insights to workplace managers into the impact of their current workspace on mental health+ concepts and show which of these concepts can be improved by optimizing the workspace. Furthermore, the tool provides insights in the potential organizational value that can be derived from implementing these optimizations.

Considering this purpose, the business case tool thus contains three main factors: the physical work environment, mental health+ and organizational performance. As indicated, the physical workspace consists of seven elements, each with its own set of measurable components. Next, mental health+ is presented as a combination of ten mental health concepts. Organizational performance is measured by means of various KPIs. Additionally, relations between the physical work environment, mental health+ and organizational performance should be included in the tool. With respect to the link between the physical workplace and mental health+, for each component of the workspace elements, an optimal, acceptable, and insufficient value was defined together with their impacts on mental health+ concepts. Regarding the effects of changes in mental health+ on organizational performance, findings that resulted from the literature review are used.

Microsoft Excel was used to construct the tool, as this program can be used to easily link values to each other and offers sufficient flexibility to quickly adapt values and effects. Furthermore, Excel is easy to use, and it is assumed that a vast majority of users has access to the program. Within the tool, a division is first made per workspace element. Within these elements, each component is assigned to a cell next to which the insufficient, sufficient, and optimal values are stated. Components that cannot be scored on a three-point scale only contain values for the insufficient and optimal conditions. Each mental health+ concept is then linked to the assessment categories by means of the IF function in Excel. Selection of a particular assessment criteria for a certain component results in the appearance of an effect (positive, negative, curvilinear) for each mental health+ concept that is affected by this particular component. Based on this effect, a potential improvement is presented per mental health+ concept. For example, if, based on the selected assessment category, stress levels are indicated as 'high', potential improvements indicate that stress levels can be reduced when this component is optimized. Finally, by means of a similar IF formula, potential improvements in mental health+ concepts are linked to organizational KPIs. For example, when potential improvements indicate that stress levels can be reduced, the KPI-overview shows that because of this reduction, improvements can be expected in terms of absenteeism and performance.

3.4 Conclusion

This chapter discussed the methods used to identify the relations between the physical work environment and mental health+ and how to combine these effects together with the findings from the literature review into a business case tool. First, a systematic review is used to analyze the findings from 133 articles on the effects of the physical work environment on mental health+. Here, the physical work environment is split up in seven elements that are each represented by a set of measurable components. For each of these components an insufficient, sufficient, and optimal value is defined regarding its impact on mental health+ concepts. Together with the findings from the literature review that focus on the link between mental health+ and organizational performance, a business case tool is set up in Microsoft Excel that allows workplace managers to assess their workplace regarding the current impact on mental health+, potential areas of improvement and the expected organizational value that results from the implementation of these improvements.

4. Results

The current chapter answers sub questions 3 and 4 in which respectively the relation between the elements of the physical workspace and mental health+ is studied and a tool is developed that provides an overview of this relation and connects it to the findings from the literature review. The first section of this chapter discusses the results of the systematic review. Section two describes the development of the business case tool. Finally, section three concludes the chapter and summarizes the main findings.

4.1 Systematic Review

The results of the systematic review will be presented in separate paragraphs, each discussing an element of the physical workspace, starting with *Office Layout and Office Design* followed by *Look, Feel and Color*; *Biophilia, Greenery, Views and Plants*; *Temperature and Thermal Comfort*; *Noise, Acoustics and Privacy*; *Indoor Air Quality and Ventilation* and *Light and Daylight*. For each element, first a definition is provided together with an overview of the components related to this element that resulted from the analysis. Next, for each component, its optimal value is discussed as well as the impacts on the specific mental health+ concepts.

Office Layout & Office Design

The workspace element ‘office layout and office design’ considers aspects related to the physical and functional settings of the work environment as well as its design (Al Horr et al., 2016). Within the literature, the following components are distinguished:

- Office type (Bodin Danielsson & Bodin, 2008; Chadburn et al., 2017; Cobaleda Cordero et al., 2019; Fassoulis & Alexopoulos, 2015; Haapakangas, Hongisto, et al., 2018; Haynes et al., 2017; Zamani & Gum, 2019);
- Workplace use (Candido, Chakraborty, et al., 2019; Candido, Thomas, et al., 2019; Haapakangas, Hallman, et al., 2018; Haynes et al., 2017; MacHe et al., 2020);
- Presence of concentration spaces/breakout rooms (Bodin Danielsson & Bodin, 2008; De Been & Beijer, 2014; Di Blasio et al., 2019; Haynes et al., 2017; Kim et al., 2016; Rasheed et al., 2019; Wiik, 2011);
- Cluster size (Bodin Danielsson & Bodin, 2008; Di Blasio et al., 2019; Herbig et al., 2016; Rasheed et al., 2019);
- Cluster separation (Cobaleda Cordero et al., 2019; Weziak-Bialowolska et al., 2018);
- Easy access to facilities (Groen et al., 2019);
- Separation of refreshment areas (Candido, Thomas, et al., 2019; Haynes et al., 2017);
- Vitality zones/aspects (Coffeng et al., 2014; Engelen et al., 2017);
- Decorative elements (Candido, Thomas, et al., 2019; Cobaleda Cordero et al., 2019; Fassoulis & Alexopoulos, 2015; Wiik, 2011);
- Workspace adjustability (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015).

Regarding office type, three main categories can be distinguished: private offices, group offices and open plan offices. A private office is described as a single room, occupied by one person. Within a group office, multiple (2-4) persons share a single room together, and an open plan office consists of a space occupied by a higher number of employees (Bodin Danielsson & Bodin, 2008; Rasheed et al., 2019; Seddigh et al., 2014). In a study on the effects of office types, Danielsson & Bodin (2008) found a relation between the type of office and mental health+ concepts *well-being* and *sleep quality*, where most positive effects were reported for the private office. The open plan office had the most negative influence on *sleep quality* and *well-being*. Other studies also reported higher levels of *productivity* (Di Blasio et al., 2019; Haapakangas, Hallman, et al., 2018; Kaarlela-Tuomaala et al., 2009; Rasheed et al., 2019; Wiik, 2011) and *concentration* (Di Blasio et al., 2019; Haapakangas, Hallman, et al., 2018; Kaarlela-Tuomaala et al., 2009; Seddigh et al., 2014; Wiik, 2011), and reductions in *stress* levels (Di Blasio et al., 2019; Haapakangas, Hallman, et al., 2018; Lindberg et al., 2018; Seddigh et al., 2014) for employees in private offices compared to open plan offices. Group offices received scores between the values related to private and open plan offices, indicating a neutral effect on these mental health+

concepts. It should however be noted that, in terms of preferred office types, differences were observed between individuals, corporate cultures and types of businesses (Bodin Danielsson & Bodin, 2008). It can be expected that for certain job activities that require high levels of collaboration group or open plan offices are preferred over private spaces, whereas this is the other way around for tasks that demand high levels of focus and accuracy (Bodin Danielsson & Bodin, 2008; Chadburn et al., 2017).

Next, studies found a relationship between the way the workspace is used in terms of seating (flexible or dedicated) and *productivity* (Candido, Chakraborty, et al., 2019; Haapakangas, Hallman, et al., 2018; Haynes et al., 2017; Kim et al., 2016) and *stress* levels (MacHe et al., 2020) among employees. Considering the workplace use, a distinction is made between offices where everyone has a personal workspace (dedicated) and flexible seating (Chadburn et al., 2017; Cobaleda Cordero et al., 2019; Fassoulis & Alexopoulos, 2015; Haapakangas, Hongisto, et al., 2018; Haynes et al., 2017). In flexible environments, employees can switch between workspaces that are designed for specific activities and tasks (Haapakangas, Hallman, et al., 2018; Haynes et al., 2019; Zamani & Gum, 2019). Since the way the workspace is used highly depends on the types of job activities conducted in the workspace, the choice for dedicated or flexible seating differs per organization. The implementation of dedicated or flexible seating to fit the needs of the organization of interest was found to enhance employee *productivity* (Candido, Chakraborty, et al., 2019; Candido, Thomas, et al., 2019; Haapakangas, Hallman, et al., 2018; Haynes et al., 2017) and decrease *stress* (MacHe et al., 2020).

Another important aspect of the office layout is the presence of concentration spaces and breakout rooms. As certain types of job activities require the possibility to move to concentration or breakout rooms, these should be present within the workspace (Bodin Danielsson & Bodin, 2008; De Been & Beijer, 2014). As indicated by various studies, availability of these spaces results in higher levels of *productivity* (Di Blasio et al., 2019; Haynes et al., 2017; Kim et al., 2016; Rasheed et al., 2019; Wiik, 2011) and *concentration* (Haapakangas, Hongisto, et al., 2018) when performing tasks and reduced levels of *stress* (Haapakangas, Hongisto, et al., 2018; Seddigh et al., 2014). Furthermore, Chadburn et al. (2017) and Haynes et al. (2017) stressed the need for breakout rooms to conduct meetings or phone calls, which is also associated with an increase in *productivity* (Candido, Chakraborty, et al., 2019) and employee *well-being* (Davis et al., 2019).

The number of occupants within a workspace was also found to be related to mental health+, in particular concerning employee *productivity* (Candido, Thomas, et al., 2019; Fassoulis & Alexopoulos, 2015) and *well-being* (Cobaleda Cordero et al., 2019; Wiik, 2011). In general, a larger number of occupants has adverse effects on these mental health+ concepts (Bodin Danielsson & Bodin, 2008; Herbig et al., 2016). Di Blasio et al. (2019) and Rasheed et al. (2019) suggest a division of the workspace in clusters of 2-5 employees with acoustic and visual separations between the different clusters to enhance *engagement* and *productivity* (Cobaleda Cordero et al., 2019; Weziak-Bialowolska et al., 2018). This is in line with earlier findings from Danielsson & Bodin (2008), who reported higher levels of collaboration within small, shared offices (4-9 people). Clusters consisting of 6 to 20 employees were found to negatively affect *productivity* and result in more difficulties *concentrating* on tasks and increases in *stress* as well as decreased *well-being* (Di Blasio et al., 2019; Seddigh et al., 2014). Open office spaces that accommodate over 20 employees were found to have the most negative effects on these mental health+ concepts (Bergström et al., 2015; Brennan et al., 2002; Di Blasio et al., 2019; Rasheed et al., 2019).

On top of that, all workplaces should have easy access to facilities that support them in their everyday tasks, as this is significantly correlated to employee *productivity* (Groen et al., 2019). Next, Candido, Thomas et al. (2019) and Haynes et al. (2017) imply a clear separation of refreshment areas from workspaces as these areas cause distractions and affect employee *productivity* as well as *concentration*.

Another aspect of office in terms of design is the implementation of vitality zones and active elements in the office, (e.g. exercise balls, standing desks, table tennis table, lounge chairs, etc.) (Coffeng et al., 2014; Engelen et al., 2017). Coffeng et al. (2014) studied mental health of employees in office environments with and without vitality zones and noticed a reduction in *stress* and *burnout* related

symptoms due to the implementation of vitality elements in the work environment. Furthermore, Engelen et al. (2017), who used the phrase ‘active design’ for similar interventions, reported an increase in *sleep quality*, *productivity*, and *engagement* because of a more vital workforce.

The implementation of decorative elements (art, natural elements, furniture, colors, photos, etc.) was also found to positively affect employee *well-being* (Cobaleda Cordero et al., 2019; Wiik, 2011) and *productivity* (Candido, Thomas, et al., 2019; Fassoulis & Alexopoulos, 2015).

Finally, the freedom to adjust the working area to personal preferences in terms of furniture, decoration and comfort (lighting, thermal comfort, air quality) resulted in higher satisfaction with the work environment and increased *productivity* among employees (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015).

Look, Feel & Color

Look, feel and color of the workspace refers to aesthetic aspects as well as textures and colors of various workspace elements (Al Horr et al., 2016). Research regarding this workspace element focused on the following component:

- Room color (Hsiao et al., 2013; Kwallek et al., 1997, 2007; Lee et al., 2018; Poursafar et al., 2019; Tonello, 2004).

Room color is associated with *productivity* (Kwallek et al., 1997; Kwallek et al., 2007; Poursafar et al., 2019), *mood* (Kwallek et al., 1997; Tonello, 2004) and *stress* (Hsiao et al., 2013; Lee et al., 2018). Based on color preferences selected by employees in office environments, it was found that, even though minor differences were observed between different personality types (Poursafar et al., 2019), predominantly white and blue colors were found to have the most positive effects on *productivity*, *mood* and *stress* (Kwallek et al., 1997; Lee et al., 2018; Poursafar et al., 2019; van der Voordt et al., 2017). However, Kwallek et al. (2007) pointed out that the magnitudes of the effects of room color on these mental health+ concepts greatly differ per employee, as this is based on their stimulus screening ability (the ability to block or neglect irrelevant aspects of the environment). On top of that, it was found that these effects are expected to decrease over time as a result of familiarity and adapting to the work environment (Kwallek et al., 2007). Furthermore, Van der Voordt et al. (2017) indicated that approximately 20% of the respondents indicated to have no particular preference regarding the colors of their work environment, indicating the dominance of other physical work environment elements over the workspace element of look, feel and color when predicting employee mental health+ concepts *productivity*, *mood* and *stress*.

Biophilia, Greenery, Views & Plants

The following workspace element considers natural elements within the work environment as well as outside views from within the workspace. The distinct measures related to this element that are recognized as predictors of various mental health+ concepts are:

- Number of plants (Gray & Birrell, 2014; Hähn et al., 2020; Kim et al., 2011; Nieuwenhuis et al., 2014; Smith & Pitt, 2009; Toyoda et al., 2020);
- Plant placement (Gray & Birrell, 2014; Hähn et al., 2020);
- Visual outdoor contact (Chadburn et al., 2017; Meir et al., 2019; Newsham et al., 2013);
- Type of views (Meir et al., 2019; Shin, 2007).

Indoor vegetation is widely recognized as a positive contributor to employee health in office buildings (e.g. Hähn et al., 2020; Nieuwenhuis et al., 2014; Shin, 2007). The presence of indoor vegetation is associated with a healthy environment, by providing a visual link to nature (Smith et al., 2011) and has a relaxing and restorative effect on people (Shin, 2007). Furthermore, plants have the ability to improve indoor air quality by removing pollutants and certain scents from the air, which creates a more comfortable environment (Smith & Pitt, 2009). Regarding mental health+ concepts, plants are found to positively affect *productivity*, *concentration*, *stress*, *well-being* and *depression* (Gray & Birrell, 2014; Hähn et al., 2020; Kim et al., 2011; Nieuwenhuis et al., 2014; Smith & Pitt, 2009; Toyoda et al., 2020).

Hähn et al. (2020) indicated that a small number of plants (1-3) per employee or desk is most beneficial for *productivity*, *concentration*, and *stress*. This is in line with earlier studies from Smith & Pitt (2009), who found that 1-3 plants per employee were generally preferred. According to Smith & Pitt, the absence of plants reduced *productivity* and *stress*. Interestingly, a higher number of plants (>3) was often perceived as chaotic or busy and reduced feelings of comfort in the workspace, which negatively affected *productivity* and *stress*, although to a lesser extent than having no plants at all. In comparison to workspaces without indoor vegetation, the implementation of 1-3 plants per desk or employee is expected to result in a 3%-15% increase in *productivity* (Hähn et al., 2020; Nieuwenhuis et al., 2014; Smith & Pitt, 2009), a 10%-20% increase in *concentration* (Hähn et al., 2020; Nieuwenhuis et al., 2014) and a reduction of *stress* symptoms of 4%-8% (Bjornstad et al., 2016; Gray & Birrell, 2014; Smith & Pitt, 2009; Toyoda et al., 2020). Furthermore, it was found that the implementation of indoor vegetation led to increased *well-being* (Thomsen et al., 2011) and slight reductions in *depression* rates (Kim et al., 2011). On top of that, after the addition of plants, Smith & Pitt (2009) observed a major decrease (>40%) in absenteeism rates, compared to offices without vegetation.

Hähn (2020) also studied the different effects of plant placement in certain areas in the office. It was found that the increases were mostly due to plant placement in the direct office environment. The implementation of greenery in breakout rooms and refreshment areas did not lead to significant improvements in *productivity* and *concentration*. On the other hand, removing the plants from these spaces led to an increase in *stress* symptoms among employees, which was also observed by Gray & Birrell (2014).

Another aspect of this particular element of the physical work environment that positively affects employee mental health+ is the visual contact to the outdoors (Chadburn et al., 2017; Dreyer et al., 2018; Meir et al., 2019; Newsham et al., 2013). It was found that, for workspaces in which employees could look outside, higher *sleep quality*, better *mood* and higher ratings of *well-being* were reported, in comparison to workspaces without a visual outdoor connection (Dreyer et al., 2018; Meir et al., 2019; Newsham et al., 2013). The types of views through these windows are also found to affect employee mental health+. According to Meir et al. (2019), pleasant views (e.g., nature) through large windows increased *productivity* and reduced feelings of *fatigue*. Furthermore, Shin (2007) observed a 4% reduction in *stress* symptoms after employees moved towards windows that offered forest views.

Temperature & Thermal Comfort

The measures related to temperature and thermal comfort of the physical work environment that were found to affect various employee mental health+ concepts are:

- Room temperature (Gupta et al., 2020a, 2020b; Kekäläinen et al., 2010; Menzies et al., 1997; Newsham et al., 2013; Reynolds et al., 2001; Valančius & Jurelionis, 2013; Wiik, 2011);
- Relative humidity (Bourbeau et al., 1997, 1997; Candido, Chakraborty, et al., 2019; Mendell et al., 2008; Newsham et al., 2013; Razjouyan et al., 2020; Wiik, 2011);
- Personal control over thermal conditions (Chadburn et al., 2017; Meir et al., 2019);
- Satisfaction with thermal conditions (Candido, Chakraborty, et al., 2019; D'Oca et al., 2018; Fassoulis & Alexopoulos, 2015; Gupta et al., 2020a, 2020b; Lou & Ou, 2019; Valančius & Jurelionis, 2013).

Studies on optimal workspace temperatures vary between 18°C to 25°C (Kim et al., 2018; Park & Gotoh, 1993; Valančius & Jurelionis, 2013), based on seasonal and topographical differences. Generally speaking, temperatures within the range of 20°C to 24°C are considered optimal (Kekäläinen et al., 2010; Newsham et al., 2013; Wiik, 2011), with adjustments of one or two degrees depending on type of season and location specific climate (Fassoulis & Alexopoulos, 2015). Office environments that deviate from this bandwidth, particularly in terms of higher room temperatures negatively affect employee *productivity* (Gupta et al., 2020b, 2020a; Kekäläinen et al., 2010; Valančius & Jurelionis, 2013), *concentration* (Kekäläinen et al., 2010; Menzies et al., 1997; Reynolds et al., 2001; Valančius & Jurelionis, 2013), *stress* (Kim et al., 2018), feelings of *fatigue* (Kekäläinen et al., 2010; Menzies et al., 1997; Reynolds et al., 2001), *sleep quality*, *mood* (Newsham et al., 2013) and *well-being* (Wiik, 2011). Regarding *productivity*, Gupta et al. (2020a-b) reported *productivity* losses up to 30% after room

temperature was increased from 20°C to 28°C. Furthermore, in terms of *concentration*, decreases of 8%-26% were observed with temperatures exceeding the optimal ranges (Kekäläinen et al., 2010; Valančius & Jurelionis, 2013). Finally, Kekäläinen et al. (2010) indicated a 20% decrease in feelings of *fatigue* among employees after temperature was lowered to more optimal values.

Relative humidity was considered optimal between 40%-55% (Bourbeau et al., 1997; Razjouyan et al., 2020; Wiik, 2011), here too with possible seasonal and geographical adjustments (Fassoulis & Alexopoulos, 2015; Park & Gotoh, 1993). Values deviating from this range, either below or above, were associated with decreased *productivity* (Candido, Chakraborty, et al., 2019; Wiik, 2011), difficulties *concentrating* on tasks (Mendell et al., 2008; Menzies et al., 1997), increasing *stress* levels up to 22% (Razjouyan et al., 2020), poor *sleep quality* (Newsham et al., 2013; Razjouyan et al., 2020), negatively affected *mood* (Newsham et al., 2013) and increases in feelings of *fatigue* (Bourbeau et al., 1997; Mendell et al., 2008).

Finally, various studies highlighted the satisfaction with thermal comfort as a predictor of self-reported *productivity* (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015; Gupta et al., 2020b, 2020a; Lou & Ou, 2019). Gupta et al. (2020a-b) noted that high levels of satisfaction with thermal comfort can improve *productivity* by 10%, whereas highly dissatisfied employees reported *productivity* losses up to 30%. A widely used scale to measure satisfaction with the thermal climate is the Predicted Percentage Dissatisfied (PPD) rate, which indicates the percentage of dissatisfied employees with regard to the indoor environment (D'Oca et al., 2018; Newsham et al., 2013; Valančius & Jurelionis, 2013). According to EN ISO 7730, this value should optimally be below 6% with an acceptable upper limit of 15% (Valančius & Jurelionis, 2013).

A main contributor to satisfaction levels was the ability to individually control thermal conditions (Chadburn et al., 2017; Meir et al., 2019). In comparison to offices without personal control, employees in offices with individually controllable thermal conditions were on average up to 85% more satisfied with the thermal comfort, which also enhanced employee *productivity* (D'Oca et al., 2018).

Noise, Acoustics & Privacy

Literature on noise, acoustics and privacy within the physical work environment also distinguishes various components:

- Background noise (Di Blasio et al., 2019; Haapakangas, Hallman, et al., 2018; Kaarlela-Tuomaala et al., 2009; Lou & Ou, 2019; Reynolds et al., 2001; Roskams et al., 2019; Seddigh et al., 2015; Wiik, 2011);
- Speech privacy (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015; Haapakangas, Hongisto, et al., 2018; Kaarlela-Tuomaala et al., 2009);
- Low frequency noise (Burt, 1996; Tesarz et al., 1997);
- Satisfaction with the acoustical quality of the environment (Chadburn et al., 2017; Lou & Ou, 2019; Wiik, 2011).

Employees prefer working in vibrant working environments (Chadburn et al., 2017; Hsiao et al., 2013), that stimulate and enable interactions and communication with coworkers. However, a more active workspace generally has higher levels of background noise is often associated with a greater number of distractions, which is not desirable when performing work-related tasks that require a high focus (Cobaleda Cordero et al., 2019; De Been & Beijer, 2014; Di Blasio et al., 2019; Haapakangas, Hongisto, et al., 2018; Wadu Mesthrige & Chiang, 2019). Background noise was indicated as a main predictor of *productivity* and *concentration*, as reported by a major share of employees (Banbury & Berry, 2005; Chadburn et al., 2017; De Been & Beijer, 2014; Di Blasio et al., 2019; Lou & Ou, 2019; Wiik, 2011). In particular, ringing phones, (phone) conversations and office equipment (e.g. printers, keyboards, etc.) were mentioned as most disturbing (Banbury & Berry, 2005; Mak & Lui, 2012; Zhang et al., 2012). In terms of affected mental health+ concepts, it was found that, in accordance with ISO 3382-3 standards, background noise levels should not exceed 48dB (Haapakangas, Hallman, et al., 2018; Kaarlela-Tuomaala et al., 2009; Lou & Ou, 2019; Seddigh et al., 2015; Wiik, 2011). Moreover, Wiik (2011) advised to set a limit of 35dB for quiet areas intended for cognitive demanding tasks. Work

environments exceeding these standards are expected to negatively affect employee mental health+, specifically regarding *productivity*, *concentration*, *stress*, *fatigue*, and *depression*. According to Wiik (2011), *productivity* rates dropped with approximately 3% when noise levels increased above desirable limits. In line with these findings, other studies (e.g., Di Blasio et al., 2019; Fassoulis & Alexopoulos, 2015) also found that background noise was an important aspect in predicting *productivity*. Likewise, increased background noise was associated with a loss in *concentration* as employees were more distracted by their surroundings (Di Blasio et al., 2019; Reynolds et al., 2001; Roskams et al., 2019), whereas office environments with improved room acoustics (within ISO standards) enabled employees to better focus on tasks (Seddigh et al., 2015). Additionally, increased background noise was found to result in higher *stress* levels among employees (Di Blasio et al., 2019; Haapakangas, Hongisto, et al., 2018), which is in line with earlier findings where improved acoustical quality led to lower levels of *stress* (Leather et al., 2003; Seddigh et al., 2015). Moreover, background noise led to increased SBS-symptoms which, apart from difficulties in *concentrating*, resulted in *fatigue* (Kaarlela-Tuomaala et al., 2009; Park & Gotoh, 1993; Perrin Jegen & Chevret, 2017; Reynolds et al., 2001) and, in the long term, *depression* (Zhang et al., 2012). Newsham et al. (2013) even indicates that there is a direct link between background noise and absenteeism, as noise levels exceeding the limits were associated with increased sick-leave among employees.

Another aspect of the acoustic environment is speech privacy within the workspace, which refers to the (in)ability to listen to conversations of co-workers and therewith affects the sense of privacy within the work environment (Kaarlela-Tuomaala et al., 2009; Newsham et al., 2013). The rate of acoustic privacy was found to be correlated with *productivity* (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015; Haapakangas, Hongisto, et al., 2018) and employee *well-being* (Haapakangas, Hongisto, et al., 2018). Kaarlela-Tuomaala et al. (2009) uses the speech transmission index (STI) to indicate speech privacy and suggests a desirable STI rate of 0.00-0.30 and least desirable STI rate of >0.60 in working areas, considering the negative effects on *productivity* and *concentration*.

Third, in various office environments, low frequency noise can occur, mostly caused by climate systems or office equipment (Burt, 1996). Low frequency noise, or infrasound, refers to sounds below the range of human hearing (20Hz) (Tesarz et al., 1997). Burt (1996) indicated that various individuals are sensitive to infrasound exposure, which results in more difficulties *concentrating* and increased levels of *fatigue*. These findings were confirmed by Tesarz (1997), who reported a 4% increase in *fatigue* among respondents after an increase in low frequency noise.

Finally, improvements in the overall acoustical quality of the workspace was associated with higher satisfaction levels (Banbury & Berry, 2005; Haapakangas, Hallman, et al., 2018; Mahdavi & Unzeitig, 2005), which was found to positively affect *productivity* (Chadburn et al., 2017; Lou & Ou, 2019; Wiik, 2011).

Indoor Air Quality & Ventilation

Research on air quality and ventilation distinguishes measures related to:

- CO₂ concentration (Bourbeau et al., 1997; Gupta et al., 2020a, 2020b; Haghghat & Donnini, 1993; Kim et al., 2018; Lu et al., 2015; Snow et al., 2019; Wiik, 2011);
- Formaldehyde concentration (Candido, Thomas, et al., 2019; Hedge et al., 1996; Kim et al., 2011; Lou & Ou, 2019; Lu et al., 2015);
- TVOC concentration (Candido, Thomas, et al., 2019; Hedge et al., 1996; Lou & Ou, 2019; Lu et al., 2015);
- Ventilation rate (Bourbeau et al., 1997; Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015; Meir et al., 2019);
- Personal control of air quality and ventilation (Brown et al., 2010; Haghghat & Donnini, 1993; Meir et al., 2019; Menzies et al., 1997);
- Satisfaction with indoor air quality and ventilation (Fassoulis & Alexopoulos, 2015; Gupta et al., 2020a, 2020b; Haghghat & Donnini, 1999; Haynes et al., 2017; Mendell et al., 2008; Newsham et al., 2013; Reijula & Sundman-Digert, 2004; Wiik, 2011).

In terms of air quality, a large body of research focused on the concentration of CO₂, formaldehyde, and total volatile organic compounds (TVOC) in the work environment and their effects on mental health+ concepts. With regard to CO₂ concentration in the workspace, ASHRAE standards (1000ppm) were considered as baseline and upper acceptable limit (Haghighat & Donnini, 1993; Wiik, 2011), after which the effects of changes to this concentration were studied. First of all, it was found that increasing the CO₂ concentration to levels exceeding the ASHRAE standards led to a reduction in *productivity* (Snow et al., 2019). This outcome was confirmed by Gupta et al. (2020a-b), who reported a loss in *productivity* of approximately 4%-12% for concentrations between 1000-1400 ppm and a reduction of 14%-24% for concentrations >1400ppm, compared to the 1000ppm baseline scenario. Changes in the CO₂ concentration also affected *concentration* and *fatigue*. Bourbeau et al. (1997) found decreased levels of *fatigue* after lowering the CO₂ concentration, which was also indicated by Lu et al. (2015), who, per 100ppm increase in CO₂, reported a 16% increase in *fatigue* and slight decreases in the ability to *concentrate*. Finally, it was found that CO₂ levels exceeding the standards led to a higher blood pressure among employees which caused an increase in *stress* (Kim et al., 2018).

Similar to CO₂ levels, ASHRAE standards were used to study the effects of changes in formaldehyde (limit: 100 µg/m³) and TVOC concentrations (Candido, Thomas, et al., 2019; Hedge et al., 1996; Lou & Ou, 2019; Lu et al., 2015). It was found that for every 100ppm increase in TVOC concentrations, *fatigue* increased by 2% (Lu et al., 2015). Similarly, *fatigue* increased with higher concentrations of formaldehyde (Hedge et al., 1996; Kim et al., 2011).

Next, various mental health+ concepts were found to be subject to ventilation rates within buildings. A ventilation rate of at least 8L/s/person was found to be both optimal in terms of *productivity* and employee satisfaction (Candido, Chakraborty, et al., 2019; Fassoulis & Alexopoulos, 2015; Meir et al., 2019). According to Meir et al. (2019), when increasing ventilation rates from 1L/s/person to 8L/s/person, *productivity* was found to increase by 1.7% for each twofold increase in ventilation rate. Besides *productivity*, suboptimal air supply was also related to higher levels of *fatigue* (Bourbeau et al., 1997; Meir et al., 2019) and employees experiencing more difficulties *concentrating* (Meir et al., 2019).

Similar to temperature and thermal comfort, individually controllable ventilation systems were found to affect several employee mental health+ concepts and increase overall satisfaction with the indoor environment (Brown et al., 2010; Meir et al., 2019). According to Menzies et al. (1997), employees reported up to 15% higher levels of *productivity* when offered the ability to personally control the indoor climate, compared to floors without individually controllable systems. Furthermore, workers reported to experience less SBS-related symptoms, indicating lower levels of *fatigue* and a higher ability to *concentrate* (Haghighat & Donnini, 1999; Menzies et al., 1997).

Finally, overall satisfaction with the indoor air quality was found to be a major component regarding several employee mental health+ concepts. Various studies reported that high dissatisfaction with the indoor air quality is considered a great distracting factor within the work environment (Fassoulis & Alexopoulos, 2015; Haghighat & Donnini, 1999; Haynes et al., 2017) negatively affecting *concentration*. In terms of *productivity*, a 12% decrease was observed when air was rated ‘stuffy’ instead of ‘fresh’ on a 7-point scale (Gupta et al., 2020b, 2020a), furthermore, Wiik (2011) reported a 3% increase in *productivity* after air quality was improved. Freshness of air was also found to affect *concentration* and feelings of *fatigue* (Haghighat & Donnini, 1999; Hedge et al., 1996; Reijula & Sundman-Digert, 2004). In a study on the effects of air conditioning systems on SBS-symptoms, Mendell et al. (2008) found that, in comparison to polluted air, exposure to fresh air was associated with a substantial reduction (70%) in the occurrence of SBS-symptoms (difficulties *concentrating* and *fatigue*). Furthermore, Newsham et al. (2013) stated that increased air quality led to improved *sleep quality* and more positive *mood* among respondents.

Light & Daylight

Light exposure is a key element in an individual’s health as it is the main influencer of the circadian rhythm (Aries et al., 2020; Figueiro et al., 2019), also referred to as ‘biological clock’ (Mills et al., 2007; Vetter et al., 2011) or ‘sleep/wake-cycle’ (Zhang et al., 2020). Disruptions in this biological rhythm due

to insufficient light exposure are associated with poor *sleep quality* (Figueiro et al., 2019; Vetter et al., 2011; Zhang et al., 2020), negative *mood* (Figueiro et al., 2019), increased feelings of *fatigue* (Figueiro et al., 2019; Zhang et al., 2020) and reductions in *productivity* and *concentration* (Aries et al., 2020; Figueiro et al., 2019). The workspace element light & daylight focusses on both artificial and natural lighting conditions in the work environment. The components related to this element distinguished in the literature are:

- Daylight exposure (Borisuit et al., 2015; Boubekri et al., 2014; Candido, Chakraborty, et al., 2019; Day et al., 2019; Figueiro et al., 2017, 2019; Hubalek et al., 2010; Veitch et al., 2008)
- Skylight (Canazei et al., 2017);
- Glare (Borisuit et al., 2015; Fostervold & Nersveen, 2008);
- Shading (Boubekri et al., 2020; Choi et al., 2019);
- Direct and indirect lighting (Boyce et al., 2006; Fostervold & Nersveen, 2008; Veitch et al., 2008);
- Correlated color temperature (Boubekri et al., 2020; Maierova et al., 2016; Mills et al., 2007; Partonen & Lönnqvist, 2000; Tonello et al., 2019; Vetter et al., 2011; Viola et al., 2008; Zhu et al., 2019);
- Illuminance (Aries et al., 2020; Boubekri et al., 2020; Candido, Chakraborty, et al., 2019; Kozaki et al., 2012; Newsham et al., 2005; Tonello, 2004; van Duijnhoven et al., 2018; Zhu et al., 2019);
- Personal control (Boyce et al., 2006; Day et al., 2019; Newsham et al., 2005; Veitch et al., 2013; Veitch & Newsham, 2000);
- Satisfaction with the lighting conditions (Boyce et al., 2006; Day et al., 2019; Newsham et al., 2005; Veitch et al., 2013; Veitch & Newsham, 2000).

Daylight exposure was found to have the highest impact on the circadian rhythm and can be measured with a circadian stimulus (CS) score, indicating the effectiveness of a certain light source in providing circadian stimulus and ranges from 0 (low) to 0.70 (high) (Figueiro et al., 2017, 2019). Figueiro et al. (2017, 2019) indicated that compared to CS scores below 0.15, a score of 0.30 and over increases *sleep quality* by 30%, which is in line with earlier findings on the effects of daylight exposure on *sleep quality* (Boubekri et al., 2014; Figueiro & Rea, 2016; Hubalek et al., 2010; Kozaki et al., 2012). Furthermore, in a study on the effects conventional blinds being replaced by electro chromatic glass, Boubekri et al. (2020) found that increased daylight exposure was associated with higher levels of *productivity*, which was also reported in other studies (Candido, Chakraborty, et al., 2019; Day et al., 2019; Nicol et al., 2006; Veitch et al., 2008).

Next, high CS scores (>0.30) were associated with a more positive *mood* (Borisuit et al., 2015; Figueiro et al., 2017; Figueiro & Rea, 2016), although the magnitude of these effects was considerably lower compared to *sleep quality* (Hubalek et al., 2010). Likewise, high daylight exposure decreased feelings of *fatigue* among employees (Figueiro et al., 2019). On top of that, Borisuit et al. (2015) also observed a more positive effect of daylight on *fatigue*, compared to exposure to artificial light sources. Moreover, employees preferred exposure to daylight over artificial light (Borisuit et al., 2015; Day et al., 2019; Maierova et al., 2016), indicating a general preference for daylight in the work environment. Besides, increased CS scores led to 5%-10% *stress* reductions (Figueiro et al., 2017), increased *well-being* among employees (Borisuit et al., 2015; Boubekri et al., 2014; Cobaleda Cordero et al., 2019) and a 20% reduction in feelings of *depression* (Figueiro et al., 2017). Considering the high influence of daylight on these mental health+ concepts, it can be argued that all workspaces should have sufficient daylight exposure, to fully support employee's mental health+. Besides CS scores, daylight exposure can also be estimated by means of a daylight factor, which is determined by the percentage of indoor illuminance compared to the outdoor illumination on a horizontal surface, with a desirable value between 2%-6% (Boubekri et al., 2014). According to Boubekri et al. (2014), sufficient daylight exposure levels can be obtained by placing workspaces in proximity to large windows, which is in line with findings related to office layout and office design, where placement near windows contributes to visual outdoor contact and enhances mental health+.

Daylight, and therewith, daylight exposure, is however subject to seasonal as well as daytime effects since daylight exposure is higher and longer in summer than in winter and decreases towards the end of the day (Adamsson et al., 2018; Borisuit et al., 2015; Figueiro & Rea, 2016). As a result, workspace daylight exposure values might be insufficient during winter or later in the afternoon. Additionally, it can be expected that, due to physical boundaries of the workplace, not all workspaces can be placed within the proximity of windows which results in insufficient daylight exposure. For such working areas, it was found that skylights are a suitable solution to increase light exposure, as oppose to conventional electric lighting (Canazei et al., 2017). According to Canazei et al. (2017), who studied the difference between skylights and conventional electric lighting in windowless offices, employee's *mood* improved by 10% and *stress* levels decreased in offices with skylights.

On the other hand, a negative effect of direct daylight exposure, is the occurrence of glare, which reduces visual comfort and therewith negatively affects *mood* (Borisuit et al., 2015), *fatigue* and *productivity* (Aries et al., 2010; Fostervold & Nersveen, 2008). To avoid the occurrence of glare, it is advised to reduce direct sunlight penetration by applying shading to the windows in the workspace (Boubekri et al., 2020; Choi et al., 2019). According to Choi et al. (2019), who studied the effects of the implementation of dynamic glass, employees reported an increase in *productivity* (21.7%), the ability to *concentrate* (12.7%), better *mood* (25.3%) and decreased feelings of *fatigue* (29.4%) compared to offices with conventional manual shading (blinds). Additionally, to avoid glare, it is recommended to implement a lighting design that uses both direct and indirect lighting as these lighting systems were also found to also positively affect employee *well-being* (Fostervold & Nersveen, 2008). Moreover, lighting systems using both direct and indirect lighting contribute to higher satisfaction levels with the workspace (Boyce et al., 2006; Veitch et al., 2008).

Another important aspect of light exposure is the correlated color temperature (CCT) of the light employees are exposed to. High CCT levels (>6500K) refer to blue-white, bright and cool colors (Boubekri et al., 2020; Partonen & Lönnqvist, 2000; Viola et al., 2008; Zhu et al., 2019) and lower levels (<3000K) are associated with lower light levels and warmer yellow colors (Mills et al., 2007; Tonello et al., 2019; Zhu et al., 2019). Two studies on the effects of CCT on employee health in the workspace found a 19.4% increase in *productivity* after increasing CCT values from 2900K to 17000K (Mills et al., 2007) or 4100K to 17000K (Viola et al., 2008). Similar results, although not quantified, were obtained by later studies with smaller differences in CCT levels ranging from 4100K to 7500K (Boubekri et al., 2020) and 3000K to 6500K (Zhu et al., 2019). Additionally, increasing CCT values to 17000K resulted in a 36.8% increase in *concentration* and 26.9% decrease in feelings of *fatigue* (Mills et al., 2007; Viola et al., 2008), which was confirmed by other studies who also reported more positive results for high CCT levels (Maierova et al., 2016; Vetter et al., 2011; Zhu et al., 2019). Furthermore, bright light conditions (>6500K) led to improved *sleep quality* (Boubekri et al., 2020; Viola et al., 2008), a more positive *mood* (Borisuit et al., 2015; Maierova et al., 2016; Partonen & Lönnqvist, 2000; Tonello et al., 2019; Vetter et al., 2011; Viola et al., 2008), a reduction in *stress* levels (Maierova et al., 2016; Tonello et al., 2019) and reduced feelings of *depression* (Partonen & Lönnqvist, 2000) compared to dim light environments (<3000K), indicating a desirable CCT level of at least 6500K in the workplace.

However, CCT has to be used with care as several studies found that, in terms of the degree of influence on the circadian rhythm, CCT of artificial light can be dominant over daylight exposure and can disrupt biological patterns (Mills et al., 2007; Vetter et al., 2011; Zhang et al., 2020). Exposure to bright light during nighttime was for instance found to result in highly disrupted sleep patterns (Vetter et al., 2011; Zhang et al., 2020). Furthermore, the magnitudes of the effects of CCT can differ per person due to an individual's sensitivity to (bright) light (Maierova et al., 2016; Tonello et al., 2019). To deal with these potential risks, several studies stressed the need for the implementation of dynamic lighting in the work environment, which regulates CCT levels during office hours (Aries et al., 2020; Zhang et al., 2020). The effects of dynamic lighting on mental health+ concepts *well-being*, *productivity*, *mood*, *stress*, and *fatigue* remain however hypothesized as research fails to find significant results to prove the potential added value of dynamic lighting. As this field is generally understudied due to the new and innovative nature of the concept and research is conducted with rather small samples, the body of research on the

effects of dynamic lighting should be expanded to gain more insights in the potential added value (Aries et al., 2020; Zhang et al., 2020).

Next, workplace illuminance was found to affect *sleep quality* (Boubekri et al., 2020; Kozaki et al., 2012), *mood* (Aries et al., 2020; Tonello, 2004; Zhu et al., 2019), *fatigue* (van Duijnhoven et al., 2018; Zhu et al., 2019) and *productivity* (Boubekri et al., 2020; Candido, Chakraborty, et al., 2019; Newsham et al., 2005). Standards on workplace illuminance levels differ per country and range between 300lx-500lx for lowest acceptable limits (Zhang et al., 2020). However, illuminance levels of 500lx are not fully optimal, as various studies found more positive results for illuminance levels exceeding this value. Regarding *sleep quality*, Kozaki et al. (2012) indicated that, compared to 500lx, *sleep quality* increased in situations with illuminance levels of 750lx, which was confirmed by Boubekri et al. (2020), who reported a positive correlation between illuminance and *sleep quality*. Furthermore, in terms of *mood*, it was found that more positive feelings were associated with illuminance levels of 800lx-1200lx, compared to 200lx-500lx conditions (Aries et al., 2020; Tonello, 2004; Zhu et al., 2019). Similarly, employees reported a decrease in feelings of *fatigue* with higher levels of illuminance (Park & Gotoh, 1993; van Duijnhoven et al., 2018; Zhu et al., 2019), although these findings were subject to individual differences due to sensitivity to lighting conditions (van Duijnhoven et al., 2018). Additionally, a positive correlation was found between illuminance and *productivity* (Boubekri et al., 2020; Candido, Chakraborty, et al., 2019; Newsham et al., 2005). As reported in these studies, positive effects of illuminance levels on productivity occur at 750lx, indicating a desirable value of 750lx in the workspace.

Furthermore, the ability to individually control the lighting conditions in the working environment was reported as an important factor in predicting employee's *mood* (Newsham et al., 2005; Veitch & Newsham, 2000) and *well-being* (Veitch et al., 2008; Veitch & Newsham, 2000). Moreover, personal control over the lighting conditions is a main predictor of overall satisfaction with the work environment (Boyce et al., 2006; Day et al., 2019; Newsham et al., 2005, 2013; Veitch et al., 2013; Veitch & Newsham, 2000), which positively correlates with employee *productivity* (Day et al., 2019; Lou & Ou, 2019) *mood* (Veitch et al., 2008, 2013), *well-being* (Veitch et al., 2008) and *engagement* (Veitch et al., 2013). It should be noted that, as indicated by Day et al. (2019), the ability to control workspace lighting was found to be more important than actually having to adjust the lighting. Furthermore, the positive effects of this aspect were only found significant for situations where lighting conditions were not satisfactory (Veitch & Newsham, 2000), indicating that personal control is only beneficial when workspace lighting conditions are rated insufficient.

Combining the effects of the workspace elements

A summary of the effects of the elements of the physical workspace on mental health+ concepts is visualized in Figure 8. Table 7 presents an overview of all components distinguished per element together with the insufficient, sufficient, and optimal values based on their impact on mental health+. The values for each of these three assessment categories is based on the reported effects on mental health+ concepts in literature. For each component, it can be seen when a certain value has a positive or negative impact on mental health+, after which these values are assigned to the corresponding assessment category. For example, regarding the number of plants per workplace, literature shows that in comparison to workplaces without plants, the placement of 1-3 plants leads to increases in productivity and concentration and reduces stress levels (Hähn et al., 2020; Smith & Pitt, 2009). Implementation of a higher number of plants also positively affects these mental health+ concepts but to lesser extent as this could lead to a more chaotic perception of the workspace (Smith & Pitt, 2009). Based on these findings, it can be concluded that, regarding the number of plants per workplace, the optimal value is 1-3 plants, an acceptable value is >3 plants and the absence of plants is considered insufficient. Another example is room temperature, for which most positive effects were measured with values between 20°C -24°C (Kekäläinen et al., 2010; Newsham et al., 2013; Wiik, 2011). Temperatures of 18°C -20°C or 25°C still have a reduced positive effect and temperatures below 18°C or above 25°C negatively affect mental health+. Thus, the optimal value is 20°C -24°C, the acceptable value is 18°C-20°C or 25°C (Kim et al., 2018; Park & Gotoh, 1993; Valančius & Jurelionis, 2013) and insufficient values are <18°C or >25°C (Gupta et al., 2020b, 2020a; Kekäläinen et al., 2010; Valančius & Jurelionis,

2013). Components that cannot be scored on a three-point scale (e.g., decorative elements are either present or not) only contain values for the insufficient and optimal conditions.

Furthermore, the table indicates the affected mental health+ concepts for each component. For effects that are quantified in the literature study, the expected percentage change is shown in the table. However, it should be noted that these values are only provided to give an indication of the size of the impact as the magnitudes of the effects depend on various subjective and situational factors. Additionally, as indicated by multiple studies, the results cannot be generalized since the impact associated with each component could greatly differ per person, as different personality types can have different responses to changes in these components (e.g., Kwallek et al., 2007; Maierova et al., 2016; Reijula & Sundman-Digert, 2004; Roskams et al., 2019; Tonello, 2004). Each effect in the table should be interpreted as the expected change in a particular mental health+ concept when this component is improved from insufficient to optimal.

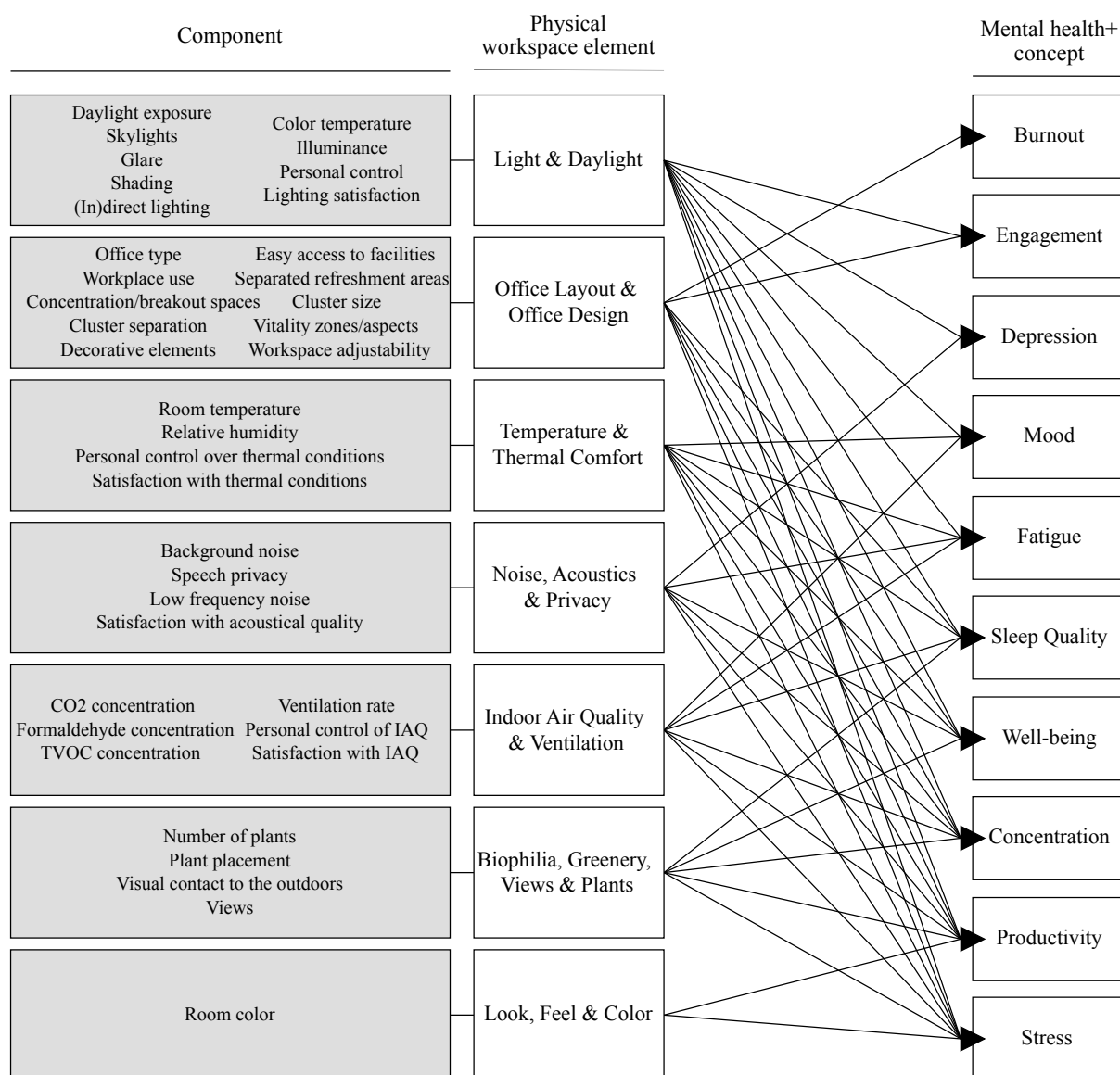


Figure 8: Effects of elements of the physical work environment on mental health+ concepts

Table 7: Overview of components per workspace element, assessment categories, and mental health+ concepts

	Insufficient	Sufficient	Optimal	Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity	
Office Layout & Office Design														
Office type	Open plan office	Group office	Private office	-	+			+				+	+	
Workplace use	Dedicated seating		Flexible seating	-								+	+	
Presence concentration spaces/breakout rooms	No		Yes	-	+							+	+	
Cluster size	>20 people	6-20 people	2-5 people	-	+				+			+	+	
Cluster separation	No	Visual or acoustic	Visual and acoustic						+			+	+	
Easy access to facilities	No		Yes									+	+	
Separated refreshment areas	No		Yes									+	+	
Vitality zones/aspects	Not present		Present	-		-		+		+		+	+	
Decorative elements	Not present		Present									+	+	
Workspace adjustability	Not adjustable		Adjustable									+	+	
Look, Feel & Color														
Room color	Dark colors	Neutral colors	Blue and white colors	-									+	
Biophilia, Greenery, Views & Plants														
Number of plants	No plants	>3 plant per desk	1-3 plants per desk	-8%								+20%	+15%	
Plant placement	No plants	Office or breakout rooms	Office and breakout rooms	-										
Visual contact to the outdoors	No visual contact	<100% of workplaces	100% of workplaces		+		+	+						
Views	No visual contact	Neutral views	Pleasant views	-4%									+	
Temperature & Thermal Comfort														
Room temperature	<18°C or >25°C	18°C -20°C or 25°C	20°C - 24°C	-	+		+	+				-20%	+26%	+30%
Relative humidity	<30% or >60%	30%-60%	40%-55%	-22%			+	+				+	+	
Personal control over thermal conditions	No		Yes										+	
Satisfaction with thermal conditions	PPD >15%	PPD 6%-15%	PPD <6%										+30%	

Noise, Acoustics & Privacy								
Background noise	Exceeding limits	Workplace <48dB Quiet areas <35dB				-	-	+3%
Speech privacy	STI >0.6	STI 0.0 – 0.3						+3%
Low frequency noise	Present	Absent					-4%	+3%
Satisfaction with acoustical quality	Dissatisfied employees	Satisfied employees						
Indoor Air Quality & Ventilation								
CO2 concentration	>1400 ppm	<1000 ppm				-	-16%	+24%
Formaldehyde concentration	Exceeding limits	ASHRAE standards					-	
TVOC concentration	Exceeding limits	ASHRAE standards					-2%	
Ventilation rate	<1L/s/person	>8L/s/person						+5%
Personal control of IAQ	No	Yes						+15%
Satisfaction with IAQ	Dissatisfied employees	Satisfied employees					-70%	+12%
Light & Daylight								
Daylight exposure	CS <0.15 or <2%	CS >0.3 or 2%-6%				-10%	+30%	-20%
Skylights (only if insufficient daylight exposure)	Conventional lighting	Use of skylights					+10%	
Glare	Present	Absent						+3%
Shading	No shading	Blinds					+25%	
Direct and indirect lighting	Only direct	Dynamic glazing					-29%	+13%
Correlated color temperature	<3000K	>6500K						+37%
Illuminance	<500lx	>750lx						+19%
Personal control	No	Yes						
Satisfaction with lighting conditions	Dissatisfied employees	Satisfied employees						+3%

4.2 Business Case Tool Development

With the information obtained from the systematic review, a business tool was developed. The aim of this tool is twofold: first, insights are provided in the effects of the current physical work environment on employee mental health+ concepts. Next, the tool indicates which aspects of the physical work environment can be optimized and what the effects of these optimizations are with respect to mental health+ concepts and organizational performance. The business case tool thus provides insights in the potential added value (mental health+ and performance) that results from changes in the physical work environment. Screenshots of the tool are provided in the Appendix.

The tool is an interactive Excel model based on the theoretical framework in Table 7. The model allows its user to score the workspace based on the seven elements of the physical work environment, their components, and the corresponding values, divided into assessment categories ‘insufficient’, ‘sufficient’ and ‘optimal’. For each component, the user needs to select which of the three assessment categories applies to the measured value. Based on this assessment, both the current impact on employee mental health+ concepts as well as the potential improvements are automatically filled in. Additionally, these potential improvements are linked to the four perspectives of organizational performance and their corresponding KPIs, as defined in Chapter 2, indicating the potential added organizational value that results from the implementation of these improvements. Assessment categories are based on the values that were derived from the systematic review. As indicated in section 4.1, it can however occur that, due to the nature of an organization, personality types or other factors, values corresponding to the assessment categories need to be adjusted. If needed, these values can easily be changed in the model, without affecting the output related to an insufficient, sufficient, or optimal assessment.

The business case tool consists of several sheets. Sheet 1 (Figure 9) introduces the tool. Here, the goal is mentioned, the setup is explained, and an explanation is provided on how the tool can be used.

Business Case Tool Healthy Office

The following tool provides insights in the impact of the physical work environment on employee mental health+ concepts *stress, well-being, burnout, mood, sleep quality, depression, engagement, fatigue, concentration and productivity* and the potential added organizational value associated with improvements in these concepts. These insights are obtained by grading the different elements of the physical work environment. The seven elements of the physical work environment are:

	Office Layout & Office Design		Noise, Acoustics & Privacy
	Look, Feel & Color		Indoor Air Quality & Ventilation
	Biophilia, Greenery, Views & Plants		Light & Daylight
	Temperature & Thermal Comfort		

Within this tool, each element has a separate page that is used to grade the components that are distinguished per element on a scale from insufficient to optimal. Only the assessment column needs to be filled in, the expected effects and impacts are automatically displayed. Next, an overview is provided of the impacts and potential improvements of each workspace component with regard to employee mental health+. Finally, insights are provided in the changes in organizational performance KPIs that result from improved mental health+ concepts by optimizing the physical work environment.

Figure 9: Business Case Tool - Homepage

Next, the seven elements of the physical work environment and their components are divided over seven sheets. In these sheets, the user needs to select an assessment criterion (insufficient, sufficient, optimal) for each component that is in line with the measured value, after which the impacts on employee mental health+ concepts are displayed, together with the potential improvements. In case a component receives an optimal score, this component cannot be improved any further and no potential improvements are shown in the table. In the figures, the assessment criterion ‘insufficient’ is selected for each component to indicate all areas of improvement. For example, for component ‘office type’ within Office Layout & Office Design, an open plan office is scored as insufficient (Figure 10).

COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Office type	Open plan office	Group office	Private office	Insufficient
Workplace use	Dedicated seating		Flexible seating	Insufficient
Presence of concentration spaces/breakout rooms	No		Yes	Insufficient
Cluster size	>20 people	6-20 people	2-5 people	Insufficient
Cluster separation	No	Visual or acoustic	Visual and acoustic	Insufficient
Easy access to facilities	No		Yes	Insufficient
Separated refreshment areas	No		Yes	Insufficient
Vitality zones/aspects	Not present		Present	Insufficient
Decorative elements	Not present		Present	Insufficient
Workspace adjustability	Not adjustable		Adjustable	Insufficient

Figure 10: Business Case Tool – Office Layout & Office Design (Assessment)

The current impact (Figure 11) indicates that this open plan office leads to high stress levels and low productivity in the current context.

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High	Low			Low				Low	Low
High									Low
High	Low							Low	Low
High	Low					Low			Low
						Low			Low
								Low	Low
High		High		Low		Low			Low
	Low								Low
									Low

Figure 11: Business Case Tool – Office Layout & Office Design (Current impact)

Next, the potential improvements (Figure 12) show that stress levels can be reduced, and productivity can be increased when this component is optimized (ABW office), as indicated by double down- or upwards arrows. In case of an acceptable score, the impacts on mental health+ concepts related to that component are displayed as ‘neutral’, indicating that these concepts are not particularly bad, but not optimal either. The potential improvements are then indicated by means of a single down- or upwards arrow instead of a double, indicating a smaller improvement compared to assessment criterion ‘insufficient’.

	Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
POTENTIAL IMPROVEMENTS										
	↓↓	↑↑			↑↑				↑↑	↑↑
	↓↓									↑↑
	↓↓	↑↑							↑↑	↑↑
	↓↓	↑↑					↑↑			↑↑
							↑↑			↑↑
									↑↑	↑↑
	↓↓		↓↓		↑↑		↑↑			↑↑
		↑↑								↑↑
										↑↑

Figure 12: Business Case Tool – Office Layout & Office Design (Potential improvements)

After assessing all seven elements of the physical work environment, sheet nine, ‘Overview’ (Figure 13), provides a total overview of the current impact for each workspace element in general. When most of the components for a certain workspace element obtains an insufficient score, the overall impact of the assessment is negative. This overall impact is only optimal when all components related to a workspace element are scored as optimal. The overview in the figure shows that, based on all components receiving assessment criterion ‘insufficient’, the current situation regarding Office Layout & Office Design leads to high levels of stress and burnout-related issues as well as low levels of well-being, sleep quality, engagement, concentration, and productivity.

	Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT										
 OFFICE LAYOUT & OFFICE DESIGN	High	Low	High		Low		Low		Low	Low
 LOOK, FEEL & COLOR	High									Low
 BIOPHILIA, GREENERY, VIEWS & PLANTS	High	Low			Low				Low	Low
 TEMPERATURE & THERMAL COMFORT	High	Low		Low	Low			High	Low	Low
 NOISE, ACOUSTICS & PRIVACY	High	Low				High		High	Low	Low
 INDOOR AIR QUALITY & VENTILATION	High			Low	Low			High	Low	Low
 LIGHT & DAYLIGHT	High	Low		Low	Low	High	Low	High	Low	Low

Figure 13: Business Case Tool – Overview of current impact

The final sheet ‘Opportunities’ (Figure 14) indicates the components that can be optimized within the workspace, based on the current impacts and links these potential improvements to the four perspectives of organizational performance and their corresponding KPIs. Optimizing the components indicated in Figure 13 reduces stress levels and burnout-related issues and increases well-being, sleep quality, engagement, concentration, and productivity, as indicated by the arrows displayed at these mental health+ concepts. As indicated in Figure 14, reductions in stress levels are then expected to decrease absenteeism, presenteeism and staff turnover and therewith recruitment and healthcare costs and increases in job satisfaction and performance. This overview thus provides insights in the potential effects of changes in the physical work environment on organizational performance via improved employee mental health+ concepts. Here too, it should be noted that these potential benefits are based on theoretical findings and are subject to situational and subjective factors and can differ per organization and individual.





	Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
POTENTIAL IMPROVEMENTS										
 OFFICE LAYOUT & OFFICE DESIGN	↓	↑	↓		↑		↑		↑	↑
 LOOK, FEEL & COLOR	↓									↑
 BIOPHILIA, GREENERY, VIEWS & PLANTS	↓	↑			↑				↑	↑
 TEMPERATURE & THERMAL COMFORT	↓	↑		↑	↑			↓	↑	↑
 NOISE, ACOUSTICS & PRIVACY	↓	↑				↓		↓	↑	↑
 INDOOR AIR QUALITY & VENTILATION	↓			↑	↑			↓	↑	↑
 LIGHT & DAYLIGHT	↓	↑		↑	↑	↓	↑	↓	↑	↑
CLIENT PERSPECTIVE										
INTERNAL BUSINESS PROCESSES PERSPECTIVE										
	↓	↓	↓		↓	↓	↓	↓		
	↑	↑	↑	↑	↑	↑	↑	↑		
	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓	↓	↓		↓	↓	↓	↓		
	↓	↓	↓			↓	↓	↓		
LEARNING & GROWTH PERSPECTIVE										
			↑		↑	↑	↑	↑		
				↑				↑		
FINANCIAL PERSPECTIVE										
	↓	↓	↓			↓	↓	↓	↑	↑
	↓	↓	↓		↓	↓	↓	↓	↑	↑

Figure 14: Business Case Tool - Opportunities

4.3 Conclusion

Within this chapter, sub questions 3 and 4 were answered providing insights in how the elements of the physical work environment relate to mental health+ and how this information, together with the findings from the literature review (Chapter 2) can be collated into a business case tool showing the potential added value of changes in the physical work environment in terms of improved mental health+ and organizational performance.

By means of a systematic review, measurable components were defined for each workspace element. Next, the relations between these components and mental health+ concepts were identified (Figure 8). For each component, insufficient, sufficient, and optimal values were defined based on their impact on mental health+ concepts (Table 7). Based on these findings, a business case tool was developed in Excel that allows CRE managers to assess the current workspace as well as design alternatives with respect to their impact on employee mental health+ and indicators of organizational performance. For each component within an element of the workspace, users select an assessment criterion (insufficient, sufficient, optimal), after which the current impact on mental health+ concepts and potential improvements are displayed. Additionally, an overview is provided, that links these potential improvements to the four perspectives of organizational performance and their KPIs. By mapping out the current impact of each component on mental health+ as well as the potential improvements in terms of mental health+ concepts and organizational performance that result from the optimization of a particular component, the tool supports the decision-making process in selecting various design alternatives or certain workspace interventions.

5. Discussion

This chapter discusses the results of the current study. First, implications for theory are discussed, which focusses on the contributions of this study to the field of corporate real estate and healthy offices. Next, study limitations are discussed.

5.1 Implications for theory

Within the field of corporate real estate and healthy offices, there is a demand for a model that provides insights in the coherence between the physical work environment, mental health+ and potential added organizational value. Each of these three concepts entails a combination of various elements that are to a certain extent related to each other. Existing literature on this subject is limited to studying the relations of one or several of these elements, but a model that collates these relations into a holistic overview was still missing. The aim of this research was therefore to develop a business case tool showing the potential effects of changes in the physical work environment on organizational performance, via improved mental health+.

In terms of the physical work environment, the relationships in the tool indicate that *light & daylight*, *office layout & office design* and *temperature & thermal comfort* potentially affect most mental health+ concepts. Improvements in these three elements of the physical workspace are thus expected to result in the strongest effects on employee mental health+ in general. Focusing on similar aspects of the workspace, Wiik (2011) already found that satisfaction with these workplace elements results in higher levels of *productivity*. Building on these findings, the current study indicates that *light & daylight*, *office layout & office design*, and *temperature & thermal comfort* not only affect *productivity* but most of the mental health+ concepts and that mental health+ is also affected by other elements of the physical workspace. In addition to that, it presents values for the components distinguished per workspace element for which mental health+ concepts can be optimized.

Within mental health+, *stress* and *productivity* are most often affected by the physical work environment. This is not surprising as stress is one of the most often reported mental health-related problems in the workplace (Cartwright & Cooper, 1997; Teasdale, 2006). Furthermore, as organizational output is often driven by performance, *productivity* is an often-occurring variable in literature. Hence, the statement that *stress* and *productivity* are most often affected by the physical work environment cannot be directly generalized, as both concepts are also the most frequently studied mental health+ concepts in existing literature. In comparison to *stress* and *productivity*, very few studies are conducted on *engagement* and *burnout* in relation to the physical workspace. Therefore, the extent to which mental health+ concepts are affected by the physical work environment cannot be compared to each other, as more research is needed to explore the effects on mental health+ concepts that are currently understudied. In a study on the impact of activity-based workplaces on *burnout* and *engagement*, Appel-Meulenbroek et al. (2020) found that both mental health+ concepts are affected by the physical work environment in terms of distractions (e.g., nuisance) and comfort (e.g., indoor climate). Furthermore, it is advised that future research should focus on further exploring how *burnout* and *engagement* are affected by the work environment (Appel-Meulenbroek et al., 2020). Given that an organization can highly benefit from an engaged workforce as this mental health+ concept is associated with most of the performance KPIs, it would be a valuable addition to the model to gain further insights in how the physical workspace elements can enhance employee *engagement*.

Next, the tool shows that improved mental health+ resulting from optimizations of the physical work environment, mostly affects the internal business processes within an organization, which are linked to the indicators *absenteeism*, *communication*, *job satisfaction*, *performance*, *presenteeism*, and *staff turnover*. These findings can be explained by the fact that the internal business processes represent the job activities and tasks executed internally to produce the products or services delivered by an organization. Since these tasks are performed by employees, improvements in staff health can be

observed in the way processes are executed, which is measured in terms of the KPIs associated with the internal business processes perspective.

Additionally, multiple relations were found between improved mental health+ and the learning and growth perspective, represented by indicators *employee innovation* and *flexibility*. From a psychological point of view, pleasant and comfortable settings increase cognitive capacity by reducing feelings of stress and pressure and improving an individual's mood (Isen, 2001). This is in line with studies by Miner & Glomb (2010) and Szalma & Harris (2008), who argued that increased cognitive capacity allows employees to quickly adapt to new situations and switch between tasks more easily, enhancing flexibility. As indicated by Ipsen (2001), more positive feelings and a better mood also provide individuals with more cognitive space to generate new ideas and supports creativity, improving an employee's innovativeness. Within the medical field, similar effects were observed. Here, physicians experience high levels of stress and exhaustion caused by the highly time-pressured environment. This resulted in reduced cognitive capacity which negatively affected the interaction between doctor and patients and reduced the quality of decisions (Gieles, 2019).

Regarding the other two perspectives of organizational performance, it is expected that improvements in internal processes and employee development enhances both the financial and customer perspective in the long term (Hladchenko, 2015; Nickel, 2011). For instance, decreased absenteeism rates and lower staff turnover reduces healthcare costs (Cooper & Dewe, 2008; Muldavin et al., 2017) and recruitment costs (Kepczynski et al., 2018; Wadu Mesthrige & Chiang, 2019). Furthermore, enhanced performance is expected to increase revenues (Gibler & Lindholm, 2012; Muldavin et al., 2017). This also applies to customer satisfaction, which, based on improved quality and services by healthy employees, is expected to increase as well (Amaratunga & Baldry, 2003; Taris, 2006).

Next, the literature study mentions the workplace model of Van der Voordt (2004), which is referred to as a suitable model to measure the impact of interventions in corporate real estate based on the four perspectives of the BSC. Even though both models use the BSC as a method to identify KPIs regarding organizational performance, the purpose of the business case tool in the current study differs from the one presented by Van der Voordt (2004). Van der Voordt's framework presents various indicators that are directly affected by changes in an organization's real estate. For example, investments in the sustainability of an asset lead to reductions in energy costs and possible improvements in a corporate's public image, or reduced travel expenses are expected due to the relocation of an office. This model also contains indicators related to employee (mental) health but presents these indicators as potential outcomes of improvements in corporate real estate. The business case model in the current research uses improved mental health+ concepts that result from optimizations of the physical workspace as a starting point and presents indicators of organizational performance that are affected by improved mental health+. Apart from a direct link between workspace interventions and organizational performance, this relationship is thus also mediated by enhanced employee mental health+. As a result, employers should thus also be concerned with improving an employee's mental health+ when optimizing the work environment, as this is beneficial to an organization, rather than investing in corporate real estate for the sake of organizational outcomes only. The main purpose of corporate real estate strategies is to support the corporate strategy and vision. With the ongoing war on talent, employees are recognized as an organization's primary asset. Ensuring a healthy workforce is therefore a vital aspect in an organization's success. Corporate real estate strategies should thus be concerned with providing a suitable workspace to employees in a healthy environment that enhances both their mental health as well as their performance.

The business case tool presented in the current research contributes to the field of corporate real estate and healthy workspaces by indicating that optimizations regarding *light & daylight*, *office layout & office design* and *temperature & thermal comfort* have the greatest impact on employee mental health+ and are expected to enhance internal business processes and employee development and, in turn, contribute to customer satisfaction and the financial success of an organization.

5.2 Limitations

Although the research is a valuable contribution to the understanding of the coherence between the physical work environment, employee mental health+ and potential added value to an organization, some limitations apply to the results.

First, the findings resulting from the systematic review are limited to the information presented in the set of 133 articles with which the analysis was conducted. In comparison to generally applied health and safety workplace standards, differences can be pointed out regarding the components distinguished per workspace element as well as the maximum acceptable upper and lower limits for values regarding optimal and acceptable standards (Boerstra et al., 2017; Horsten et al., 2016). For example, regarding ventilation rates, articles indicate an optimal value of at least 8L/s/person (e.g. Meir et al., 2019), whereas health and safety services currently indicate an acceptable limit of at least 10L/s/person (Boerstra et al., 2017; Horsten et al., 2016). It should however be noted that the workplace standards from health and safety services are not limited to mental health only, but also focus on social and physical health. On top of that, it is assumed that with the practical implementation of the workplace standards, an extra safety margin is applied to ensure a positive outcome regarding employee health in general.

Secondly, differences between the articles studied in the systematic review can be observed in workplace standards and values over time as well as their effects on mental health+ concepts. For example, air quality values from the 1990's were highly decreased by employees smoking in the workplace, resulting in many health related complaints (Bourbeau et al., 1997; Hedge et al., 1996; Hori et al., 1993). Over time, due to improved ventilation systems and changes in regulations which prohibit employees from smoking within the office environment, the perception of acceptable air quality has changed. Due to the increasing interest and growing body of research on mental health in the workplace and potential changes in workplace standards, values presented in this research should be evaluated over time to see whether they are still in line with present day standards. On top of that, magnitudes of effects are highly subject to subjective and situational factors and greatly differ per individual, building, organization, and location. Especially in terms of the indoor climate, differences in optimal values for temperature, relative humidity and light exposure were observed between studies conducted in different climates. Studies executed in countries with warm and humid climates generally have higher indoor temperatures and relative humidity, compared to studies conducted in countries with colder climates. Practical implementation of the tool should thus always take place in consultation with the organization it is applied to, to adjust the optimal values to the outdoor climate, determine how the various components and values should be assessed and to define the potential impacts of certain interventions.

Furthermore, satisfaction with the indoor environment in terms of thermal sensation, acoustical quality, air quality and lighting conditions was found to be a major predictor of the mental health+ concept *productivity*. The satisfaction with these elements can be described as the subjective experience of the objective components discussed at each workspace element. This is in line with the person-environment fit theory, which describes the extent to which a person matches with his or her environment and distinguishes between a subjective (perceived) and objective fit (Caplan, 1987). However, literature analyzed in the current study did not discuss the subjective assessment of workspace elements related to office layout & office design, biophilia, greenery, views & plants and look, feel & color. Yet, considering the person-environment fit theory, it can be expected that satisfaction with these three elements could also relate to employee mental health+ separately from its direct objective effect.

Next, literature is not consistent in the hierarchy or rating of the elements of the physical work environment in terms of their impact on mental health+ (Figure 15). Moreover, literature on such a rating does not always consider all seven elements of the physical workspace as discussed in the current study, as biophilia, greenery, views & plants and look, feel & color are usually categorized under office layout & office design or are not considered in these studies. Therefore, these two elements are not included in the figure. Besides, as the effects of interventions are subject to subjective and situational factors, the

rating of workspace elements can differ per organization. This complicates the decision-making process in choosing a certain intervention when several optimizations are possible.

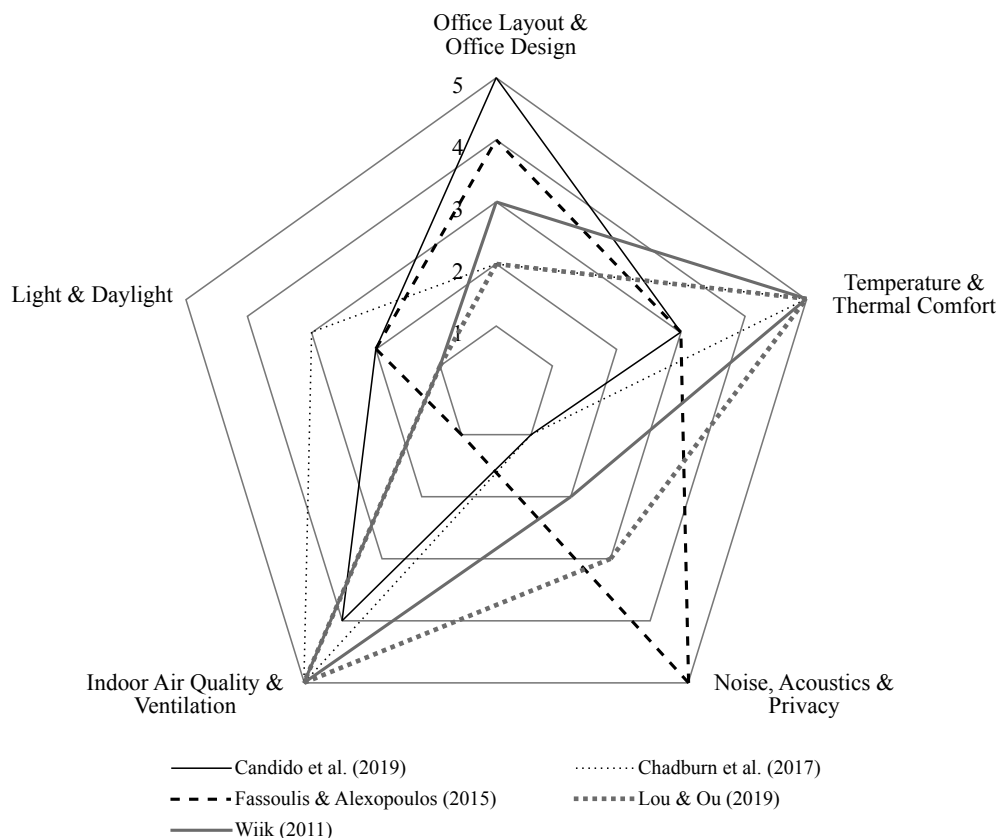


Figure 15: Ranking of physical workspace elements according to various studies (higher numbers indicate higher ranking).

A potential approach for this issue is offered in a model by Kim & De Dear (2012) (Figure. 16). Based on the Kano model for customer satisfaction, Kim & De Dear (2012) introduced a model in which aspects of the indoor environmental quality (IEQ) are categorized as basic factors, proportional factors, and bonus factors based on their impact on employee satisfaction with their work environment:

- **Basic Factors:** These can be thought of as minimum requirements. Occupants only notice these factors if they are deficient or defective in some way. They don't necessarily enhance overall satisfaction, but they can cause dissatisfaction when they are not fulfilled. Good performance on Basic Factors is a necessary (but not sufficient) condition for occupants' satisfaction.
- **Bonus Factors:** Bonus Factors go beyond minimum expectations, so when a product performs very well on Bonus Factors, there is a strong positive effect on occupant's satisfaction. However, poor performance on these factors doesn't necessarily result in dissatisfaction.
- **Proportional Factors:** Occupant's satisfaction level changes proportionally according to the performance of these factors. When they perform well, occupants will be satisfied. And when they perform poorly, occupants will be dissatisfied. (Kim & de Dear, 2012 p.34)

In an analysis of data on occupant satisfaction with the IEQ (43,021 respondents from 351 office buildings), Kim & De Dear (2012) found that thermal comfort and noise levels can be classified as basic factors as these are minimum requirements within the work environment. Next, air quality and lighting conditions showed a linear correlation with satisfaction levels, and hence, these aspects are categorized as proportional factors. No IEQ factors were identified as bonus factors. However, the Kano model does not contain all elements and components of the physical work environment as focused on in the current study. An adaptation of the model including these aspects with a focus on mental health+ instead of occupant satisfaction could enhance the decision-making process in prioritizing certain interventions that are suggested after completion of the business case tool. In this case, optimization measures should

be implemented for basic factors before improving proportional or bonus factors, as these are necessary requirements to enhance employee mental health+.

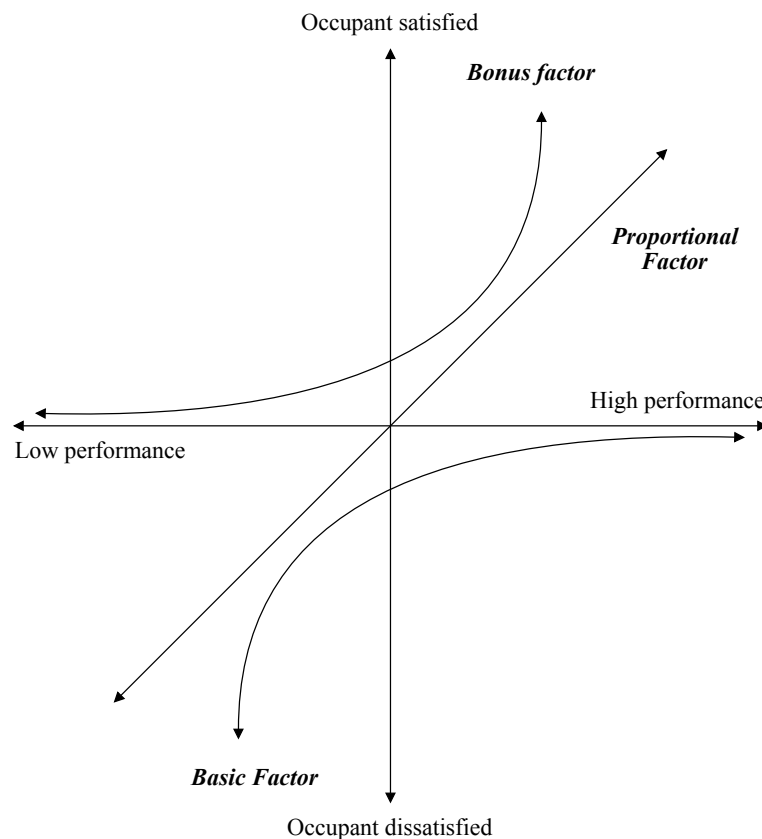


Figure 16: Kano model for occupant's satisfaction with IEQ variables (Kim & de Dear, 2012)

Additionally, this research did not consider the possible correlations between factors within the physical work environment, mental health+ and organizational performance. Regarding the physical work environment, it can be assumed that optimizations within a certain element could lead to improvements in another one as well. For example, optimizations in terms of office layout and design can be expected to lead to better acoustic quality and reduced background noise (Chadburn et al., 2017; Di Blasio et al., 2019). Similarly, within mental health+, concepts are expected to also be correlated with each other as, for example, poor sleep quality overnight could possibly affect an individual's mood and feelings of fatigue the next day (Barnes & Watson, 2019; Caldwell et al., 2019). Insights in these potential correlations can increase the accuracy of expected effects presented in the output of the business case tool. Furthermore, these insights could further enhance the decision-making process by steering towards optimizations in certain workplace elements or mental health+ concepts that lead to improvements in other aspects as well.

Finally, the monetary costs of interventions are not considered in the business case tool, even though these may be crucial in the decision to implement a certain intervention or not. By indicating the investment associated with a certain optimization, more accurate cost-benefit analyses can be made, showing both the required investment and potential outcomes of these interventions.

To summarize, differentiating between basic, proportional and bonus factors together with insights in correlations between factors and specifications of the implementation costs of interventions, can be used to prioritize the optimizations that result from the business case tool. These insights can be used to choose between certain measures based on their impacts on employee mental health+ and organizational performance. On the contrary, it would also be possible for an employer to rank the four perspectives of organizational performance or their corresponding KPIs in a similar way as presented in Figure 15, after which the interventions are selected that are most influential to these aspects.

6. Conclusions and Recommendations

This final chapter concludes the research and consists of three sections. The first section draws a conclusion based on the main findings. Section two provides recommendations for future research after which section three discusses recommendations for practice.

6.1 Conclusion

This study aimed to explore the underlying mechanisms between the physical work environment, employee mental health+ and organizational performance, and to use this information to develop a business case tool indicating the potential added organizational value of changes in the physical work environment through improved mental health+.

Results indicate that respectively *light & daylight*, *temperature & thermal comfort*, and *office layout & office design* affect most mental health+ concepts. Many improvements in employee mental health+ in general might thus be obtained by optimizing these three workspace elements. Considering the mental health+ concepts, these improvements are expected to be observed mostly in terms of reduced *stress* levels and enhanced *productivity* as, according to the literature, these two concepts are most often affected by the physical work environment. In turn, enhanced mental health+ mainly affects the *internal processes* of an organization together with *employee growth*. In the long term, these improvements are expected to lead to higher *customer satisfaction*, *revenue growth* and reductions in *healthcare* and *recruitment costs*.

The relationships between the physical work environment, mental health+ and organizational performance (Figure 17) were collated into a business case tool, which allows CRE managers to assess both their current workspace and one or more design alternatives on their expected impact on employee mental health+. Furthermore, insights are provided on the effects of changes in the physical workspace on performance KPIs, via improved mental health+ concepts.

Concluding, the business case tool presented in this research offers workplace managers the possibility to gain insights in the effects of the physical workspace on employee mental health+ and in which domain optimizations can be made. These improvements are first related to improved mental health+, which is then linked to potential added organizational value. The lack of insights in the potential added organizational value currently prevents employers from investing in mental health+ by improving the physical work environment. Consequently, measures to optimize the workspace in order to support mental health+ are perceived as an expense rather than an investment, despite the general understanding that a healthy workforce is crucial to an organization. By providing first insights in the potential added organizational value of a healthier workforce, the business case tool presented in the current research enhances the transition where workspace interventions are no longer perceived as expense but as an investment.

6.2 Recommendations for Future Research

The results in this research contribute to a more advanced understanding of how the physical work environment, mental health+ and organizational performance relate to each other. However, considering that this study provides first insights in the holistic set of relations between these three aspects, results should be validated. First, by means of case-studies, it can be tested whether the effects in the model are also observed in practice. Since the size of the impact is subject to several factors (type of person, building, organization, location, etc.), it would be a valuable addition to perform these studies for various organizations in different contexts. An average score per discipline or type of organization offers workplace managers the possibility to compare their workplace scores to those from similar organizations. Additionally, impacts are currently indicated as a direction (positive, negative, or neutral). Data resulting from application of the tool can be used to further specify these relations and provide insights in the magnitudes of the effects.

Next, as mentioned in the discussion, studies on the correlation between mental health+ concepts are expected to give more insights in how these concepts support each other and which concepts to aim for when improving employee mental health+, so that others are affected as well. Likewise, correlations are also expected between physical workspace elements and could thus be reviewed in-depth as well.

Finally, research should focus on defining the size of the share of mental health+ within an employee's overall health, since next to a mental component, a physical and social or emotional component are distinguished as well. Similarly, next to the physical workspace, the overall work environment also considers organizational culture and leadership, which can also be expected to affect an employee's mental state to a certain extent. It is therefore important to gain insights in the extent to which mental health+ is affected by the physical workspace in comparison to corporate culture and leadership and to which extent an improved mental state contributes to an employee's overall health. These insights allow for more accurate expectation patterns with respect to the scale of the effects that result from the implementation of optimizations.

6.3 Recommendations for Practice

Due to the increasing number of health-related issues in the workspace, there is a growing interest in the responsibility of employers in providing a healthy workplace to their employees. The results of the current study show that within this healthy workplace, there is an important role to play for the physical work environment. These findings support the perception that the purpose of CRE goes beyond facilitating a space to work and can positively contribute to an organization on a strategic level. After all, investing in employee health by optimizing the physical workspace contributes to the internal processes of an organization, employee growth, customer perceptions and financial performance.

In the development of CRE strategies, the current aim is too much focused on short term cost reductions and efficiency. Every amount invested should currently be justified by the monetary value that will result from the investment. Even though such strategies might lead to positive financial outcomes in the short term, these investments will lead to negative effects in the long term (e.g., reductions in health and satisfaction) which cannot always be directly expressed in monetary terms but are essential to an organization. Real estate strategies should thus move away from the perception that investments can only be made when the financial output exceeds the invested amount of money and should thus also consider the strategic value of investments.

The business case tool presented in the current study supports this belief by justifying investments in employee health through providing insights into the potential added financial as well as strategic value that results from these investments. However, the main purpose of these investments still revolves around optimizing organizational performance in which improving employee health is a means to an end. Ultimately, the general perception should be that employees are an organization's most important asset and that investments should be made for the main purpose of supporting employee health itself.

The new workplace strategies that are being developed due to the current COVID-19 pandemic, provide an excellent opportunity for the implementation of the business case tool for healthy offices. By using this tool in the development of these strategies and in redefining the physical workspace, workplace managers can ensure a healthy work environment that positively contributes to a healthy workforce.

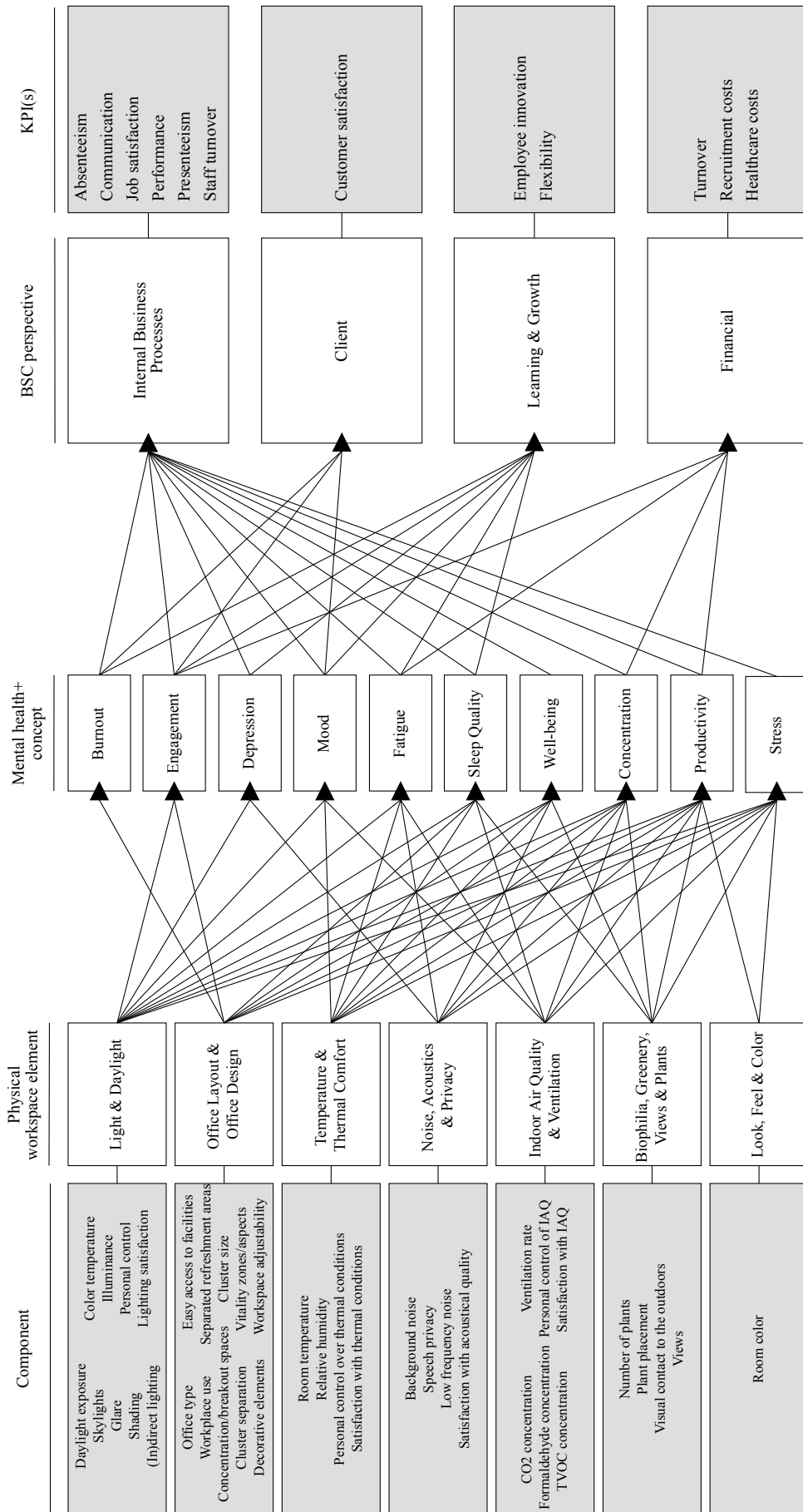


Figure 17: relations between the physical work environment, mental health+ and organizational performance.

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Appendix – Business Case Tool

Homepage

Business Case Tool Healthy Office

The following tool provides insights in the impact of the physical work environment on employee mental health+ concepts *stress, well-being, burnout, mood, sleep quality, depression, engagement, fatigue, concentration* and *productivity* and the potential added organizational value associated with improvements in these concepts. These insights are obtained by grading the different elements of the physical work environment. The seven elements of the physical work environment are:



Office Layout & Office Design



Noise, Acoustics & Privacy



Look, Feel & Color



Indoor Air Quality & Ventilation



Biophilia, Greenery, Views & Plants



Light & Daylight




Temperature & Thermal Comfort

Within this tool, each element has a separate page that is used to grade the components that are distinguished per element on a scale from insufficient to optimal. Only the assessment column needs to be filled in, the expected effects and impacts are automatically displayed. Next, an overview is provided of the impacts and potential improvements of each workspace component with regard to employee mental health+. Finally, insights are provided in the changes in organizational performance KPIs that result from improved mental health+ concepts by optimizing the physical work environment.

Office Layout & Office Design

Components

 OFFICE LAYOUT & OFFICE DESIGN				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Office type	Open plan office	Group office	Private office	Insufficient
Workplace use	Dedicated seating		Flexible seating	Insufficient
Presence of concentration spaces/breakout rooms	No		Yes	Insufficient
Cluster size	>20 people	6-20 people	2-5 people	Insufficient
Cluster separation	No	Visual or acoustic	Visual and acoustic	Insufficient
Easy access to facilities	No		Yes	Insufficient
Separated refreshment areas	No		Yes	Insufficient
Vitality zones/aspects	Not present		Present	Insufficient
Decorative elements	Not present		Present	Insufficient
Workspace adjustability	Not adjustable		Adjustable	Insufficient

Current Impact


Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High	Low			Low				Low	Low
High									Low
High	Low							Low	Low
High	Low					Low			Low
						Low			Low
								Low	Low
High		High		Low		Low			Low
	Low								Low
									Low

Potential Improvements

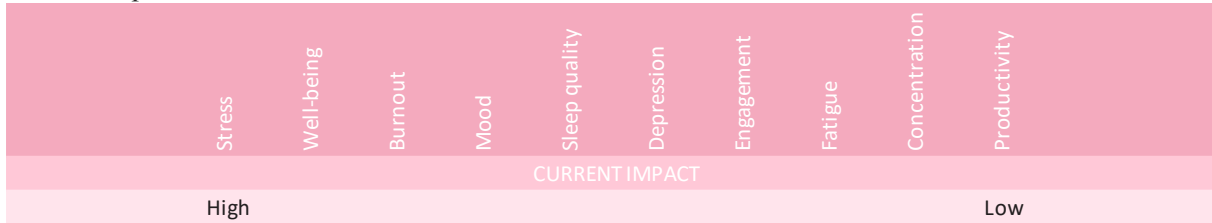
Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
POTENTIAL IMPROVEMENTS									
↓↓	↑↑			↑↑				↑↑	↑↑
↓↓									↑↑
↓↓	↑↑							↑↑	↑↑
↓↓	↑↑					↑↑			↑↑
						↑↑			↑↑
								↑↑	↑↑
↓↓		↓↓		↑↑		↑↑			↑↑
	↑↑								↑↑
									↑↑

Look, Feel & Colors

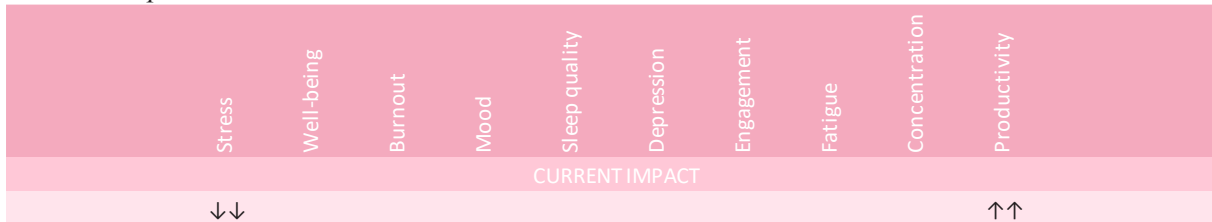
Components

 LOOK, FEEL & COLORS				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Room color	Dark colors	Neutral colors	Blue and white colors	Insufficient

Current Impact




Potential Improvements



Biophilia, Greenery, Views & Plants

Components

 BIOPHILIA, GREENERY, VIEWS & PLANTS				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Number of plants	No plants	>3 plants	1-3 plants	Insufficient
Plant placement	No plants	Office or breakout rooms	Office and breakout rooms	Insufficient
Visual contact to the outdoors	No visual contact	<100% of workplaces	100% of workplaces	Insufficient
Views	No visual contact	Neutral views	Pleasant views	Insufficient

Current Impact


Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High								Low	Low
High	Low			Low					
High									Low

Potential Improvements

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
8%↓↓								20%↑↑	15%↑↑
↓↓									
	↑↑			↑↑					
4%↓↓									↑↑

Temperature & Thermal Comfort

Components

 TEMPERATURE & THERMAL COMFORT				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Room temperature	<18°C or >25°C	18°C - 25°C	20°C - 24°C	Insufficient
Relative humidity	<30% or >60%	30%-60%	40%-55%	Insufficient
Personal control over thermal conditions	No		Yes	Insufficient
Satisfaction with thermal conditions	PPD >15%	PPD 6%-15%	PPD < 6%	Insufficient

Current Impact


Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High	Low		Low	Low			High	Low	Low
High			Low	Low			High	Low	Low
									Low
									Low

Potential Improvements

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
↓↓	↑↑		↑↑	↑↑			20%↓↓	26%↑↑	30%↑↑
22%↓↓			↑↑	↑↑			↓↓	↑↑	↑↑
									↑↑
									30%↑↑

Noise, Acoustics & Privacy

Components

 NOISE, ACOUSTICS & PRIVACY				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Background noise	Exceeding limits		Workplace <48dB Quiet areas <35dB	Insufficient
Speech privacy	STI >0.6	STI 0.3-0.6	STI 0.0 – 0.3	Insufficient
Low frequency noise	Present		Absent	Insufficient
Satisfaction with acoustical quality	Dissatisfied employees		Satisfied employees	Insufficient

Current Impact


Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High					High		High	Low	Low
	Low						High	Low	Low
									Low

Potential Improvements

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
↓↓					↓↓		↓↓	↑↑	3%↑↑
	↑↑							↑↑	↑↑
							4%↓↓	↑↑	
									↑↑

Indoor Air Quality & Ventilation

Components

 INDOOR AIR QUALITY & VENTILATION				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
CO2 concentration	>1400 ppm	1000 – 1400 ppm	<1000 ppm	Insufficient
Formaldehyde concentration	Exceeding limits		ASHRAE standards	Insufficient
TVOC concentration	Exceeding limits		ASHRAE standards	Insufficient
Ventilation rate	<1L/s/person	1-8L/s/person	>8L/s/person	Insufficient
Personal control of IAQ	No		Yes	Insufficient
Satisfaction with IAQ	Dissatisfied employees		Satisfied employees	Insufficient

Current Impact


Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High							High	Low	Low
							High		
							High	Low	Low
							High	Low	Low
			Low	Low			High	Low	Low

Potential Improvements

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
↓↓							16%↓↓	↑↑	24%↑↑
							↓↓		
							2%↓↓		
							↓↓	↑↑	5%↑↑
							↓↓	↑↑	15%↑↑
			↑↑	↑↑			70%↓↓	70%↑↑	12%↑↑

Light & Daylight

Components

 LIGHT & DAYLIGHT				
COMPONENT	INSUFFICIENT	SUFFICIENT	OPTIMAL	ASSESSMENT
Daylight exposure	CS<0.3 or <2%		CS >0.3 or 2%-6%	Insufficient
Skylights (only if insufficient daylight exposure)	Conventional lighting		Use of skylights	Insufficient
Glare	Present		Absent	Insufficient
Shading	No shading	Blinds	Dynamic glazing	Insufficient
Direct and indirect lighting	Only direct		Direct and indirect	Insufficient
Correlated color temperature	<3000K	3000K – 6500K	>6500K	Insufficient
Illuminance	<500lx	500lx – 750lx	>750lx	Insufficient
Personal control	No		Yes	Insufficient
Satisfaction with lighting conditions	Dissatisfied employees		Satisfied employees	Insufficient

Current Impact

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
High	Low		Low	Low	High		High		Low
High	Low		Low				High		Low
			Low				High	Low	Low
	Low								
High			Low	Low	High		High	Low	Low
			Low	Low			High		Low
	Low		Low						
	Low		Low			Low			Low

Potential Improvements

Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
CURRENT IMPACT									
10%↓↓	↑↑		↑↑	30%↑↑	20%↓↓		↓↓		↑↑
↓↓			10%↑↑				↓↓		↑↑
			↑↑				↓↓		↑↑
			25%↑↑				29%↓↓	13%↑↑	22%↑↑
	↑↑								
↓↓			↑↑	↑↑	↓↓		27%↓↓	37%↑↑	19%↑↑
			↑↑	↑↑			↓↓		↑↑
	↑↑		↑↑						
	↑↑		↑↑			↑↑			↑↑

Overview of Current Impact

		Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
		CURRENT IMPACT									
	OFFICE LAYOUT & OFFICE DESIGN	High	Low	High		Low		Low		Low	Low
	LOOK, FEEL & COLOR	High									Low
	BIOPHILIA, GREENERY, VIEWS & PLANTS	High	Low			Low				Low	Low
	TEMPERATURE & THERMAL COMFORT	High	Low		Low	Low			High	Low	Low
	NOISE, ACOUSTICS & PRIVACY	High	Low				High		High	Low	Low
	INDOOR AIR QUALITY & VENTILATION	High			Low	Low			High	Low	Low
	LIGHT & DAYLIGHT	High	Low		Low	Low	High	Low	High	Low	Low

Overview of Opportunities

	Stress	Well-being	Burnout	Mood	Sleep quality	Depression	Engagement	Fatigue	Concentration	Productivity
POTENTIAL IMPROVEMENTS										
 OFFICE LAYOUT & OFFICE DESIGN	↓	↑	↓		↑		↑		↑	↑
 LOOK, FEEL & COLOR	↓									↑
 BIOPHILIA, GREENERY, VIEWS & PLANTS	↓	↑			↑				↑	↑
 TEMPERATURE & THERMAL COMFORT	↓	↑		↑	↑			↓	↑	↑
 NOISE, ACOUSTICS & PRIVACY	↓	↑				↓		↓	↑	↑
 INDOOR AIR QUALITY & VENTILATION	↓			↑	↑			↓	↑	↑
 LIGHT & DAYLIGHT	↓	↑		↑	↑	↓	↑	↓	↑	↑
CLIENT PERSPECTIVE										
			↑	↑			↑			
INTERNAL BUSINESS PROCESSES PERSPECTIVE										
	↓	↓	↓		↓	↓	↓	↓		
	↑	↑	↑	↑	↑	↑	↑	↑		
	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	↓		↓		↓	↓	↓	↓		
	↓	↓	↓			↓	↓	↓		
LEARNING & GROWTH PERSPECTIVE										
			↑		↑	↑	↑	↑		
				↑				↑		
FINANCIAL PERSPECTIVE										
	↓	↓	↓			↓	↑	↑	↑	↑
	↓	↓	↓		↓	↓	↓	↓		

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