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How the Physical Work Environment Can Affect Individual Productivity

Master's Thesis

University of Stavanger

Spring 2017

FACULTY OF SOCIAL SCIENCES,
UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
MSc Business Administration	Strategic Management
	IS THE ASSIGNMENT CONFIDENTIAL? No

TITLE:
How the Physical Work Environment Can Affect Individual Productivity.

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Preface

This thesis was inspired by our interest in motivational factors and human behavior, and the idea surfaced one day while sitting in a group room at the University of Stavanger. We noticed that we got drained of energy faster than usual, compared to when working on assignments at home. One of the factors that sparked an interest was the use of colors in the physical work environment at campus. This thesis represents the end of a two-year master's degree in Business Administration with the specialization of Strategic Management, at the University of Stavanger.

We would like to give recognition to all the people that participated in our pre-test and pilot-exercise, we feel lucky that so many were willing to give up their time for free to help us with our thesis.

A special thanks to our thesis advisor Einar K. Brandsdal. We also want to thank Professors Thomas Laudal and Espen Olsen for their valuable input. Lastly, we want to thank our friends and family for supporting us throughout this semester, with a special thanks to A. Bjørg Kristinsdottir for invaluable input and guidance.

We are grateful for the experience and knowledge we have gained the past two years.

Stavanger, June 2017

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Abstract

The topic of this thesis is about how the physical work environment affects individual productivity, and with focus on productivity through the well-being aspect of individuals. The thesis has a theoretical approach with a pilot-exercise including a pilot experiment and questionnaire. This approach was chosen as the research question is comprehensive, and with the timeframe to complete this thesis. A theoretical approach gives the possibility to further go into the subject, and the pilot-exercise gives insight into how a larger-scale study on this topic could be conducted. Further, the physical work environment contains several elements that can affect an individual's productivity and well-being, so the physical work environment aspect has been restricted to only looking at one factor, which is the color aspect. The thesis research question is:

"How does the physical work environment affect individual productivity?"

The hypothesis in the thesis focuses on how color affects individual well-being, and to test for this a pilot-exercise was used, where the objective is to provide learning points that can be used in a full-scale study. There will be used a quantitative approach, where both a pilot experiment and questionnaire is created to collect the data needed, which can contribute with learning points. In total the pilot-exercises had a sample of thirty participants that were divided between two different color environments, the sample was too small to give any results but it will give learning points regarding the methods used.

A statistical program, Stata, was used to analyze the results from the pilot-exercise, where the data from the pilot experiment and questionnaire were analyzed by using an independent samples t-test. An analysis was conducted, even though knowing that the sample was too small to give any real conclusion if the hypothesis should be rejected or not.

The results from the analyses done on the pilot experiment and questionnaire gave no significant results, which was expected due to the sample size used, but it did provide valuable insight into how a larger-scale study could be conducted. The theoretical approach showed that the physical work environment impacts people both physically and psychologically, and that the individual productivity is affected by the physical work environment both negatively and positively.

Table of contents

1.0 Introduction

The technology that is available today has changed the way people work, it gives them the opportunity to work from anywhere. Still most people choose to travel back and forth from the office daily, because it seems people seek a place where they can engage with others, share knowledge and generate ideas. A place where an essential aspect of the work is human aggregation, friction and interaction of the mind. Because of these factors, the conditions of the physical workplace are a more important aspect of an organization now than ever (Ratti & Claudel, 2016). The second greatest financial cost an organization possesses is the design of the physical work environment (McCoy, 2005), which is frequently designed in neutral backgrounds (Kwallek, et.al., 1997). In this modernized industrial world, there is a lack of recognition on how office workers are affected by the physical work environment (Ashkanasy et al., 2014).

One office design that companies have been implementing nowadays is the open-plan office, as this lowers costs and is more convenient than cell-offices (Kamarulzaman, 2011). This has had a negative effect on the employee's efficiency as only 15% of Norwegian employees report that they are more efficient in this type of environment (Kaspersen, 2014). The idea behind open-plan offices, in addition to the reduction in construction and equipment costs, is to provide an environment that would increase work efficiency and further the communication. Feelings of crowdedness and loss of privacy are likely to emerge in the open-plan offices, and can eventually result in dissatisfaction and negative reactions demonstrated by the employees. Several studies point out that open-plan offices are often linked to decreased job satisfaction, lower perceived privacy, and reduced motivation (Kamarulzaman, 2011).

Because of an ever-changing environment, organizations are required to constantly change to stay ahead of their competitors (Petrou et al., 2016; Chawla & Lenka, 2015). The employees are one of the most essential resources an organization has (Heery & Noon, 2008), and trends have shown that one of the key factors of competitiveness are the morals and motivations of the employees (Law, 2016). These factors include managing the individual behavior and performance to work towards achieving the organization's goals, and enhance effectiveness (Law, 2016; Duignan, 2016).

The topic of this thesis is the physical work environment, with focus on individual productivity and well-being. This topic was chosen because it seems that when organizations design offices the main focus is on how to make it cost efficient, which like in the case of the open-office does not always benefit the employees. As employees are one of the most essential resources an organization possesses, the focus of this thesis is to examine how the physical work environment can have positive effects for both the organization and the employees.

The following research question has been selected for this thesis:

"How does the physical work environment affect individual productivity?"

Chapter two of this thesis will introduce relevant theories linked to the physical work environment, individual productivity and the aspect of well-being. In chapter three the method for gathering the information for the pilot-exercise will be presented. In chapter four, the analysis, results and learning points for the pilot exercise will be presented. The discussion part of the thesis will be in chapter five, chapter six will contain a conclusion, and lastly there will be a bibliography and appendix.

2.0 Theoretical Chapter

Nowadays, management trends are focusing on employee morals and motivations to increase organizational competitiveness (Law, 2016). This is probably connected with the positive effects that can result from having motivated employees, this includes higher profitability, lower turnover rate and reduced production cost (Schuler & MacMillan, 1984). This is connected to the topic of this thesis, which centers around theories of the physical work environment with focus on individual productivity and well-being.

2.1 Historical Perspective on Productivity

One of the main characteristics of the first industrial revolution was the growth in productivity (Jensen, 1993). In Adam Smith's "An inquiry into the Nature and causes of the wealth of nations" from 1776, he writes about how the concept of the division of labor had a positive effect on productivity. The concept was based on having several people work in different units on the same product and that it would have an improvement on the productivity. This would lead to more output in a shorter amount of time, rather than if one person made the whole product by themselves. Smith mentions different reasons for this increase in productivity, one of them being specialization, because the workers only were responsible for a few parts in the production of the product, they would excel in their job. The theory also includes that people are willing to do this monotonic work, because humans have the need to obtain stuff by trading or exchanging, and given that they are compensated for the labor, the workers are content. In other words, the paycheck becomes an incentive that motivates people to work.

Smith's view was taken a step further by Fredrick Winslow Taylor, as he used time and motion studies to find a way of making labor more productive (Schwartz, 2015). Taylor is considered the father of what is called Scientific Management, which is a way to manage labor by scientifically studying how to do the job in the most efficient way where the needs of the workers are included, and at the same time get as much as possible done. These studies showed the optimal way of working, and how much one person that is scientifically suited to do the job should be able to accomplish in one day's work. The most substantial change compared to Smith's view, is that instead of the workers having the greater part of the responsibility and knowledge, the new way of managing the responsibility of the work would

almost be equally divided between the managers and the workers. But there were some heavier duties that the managers had to conduct, which was:

1. They needed to establish science to every aspect of a man's work.
2. Scientifically select a workman, and then train, help and teach him how to do the job.
3. Cooperate with the workers to make sure that the principles of the science that had been developed was properly followed.

Also, the managers needed to gather all the information needed for the work to be executed, and make rules, laws and formulas that would help the workers. By being scientifically able to find the optimal amount of one day's work, it was possible to make tasks that would give the workers an incentive to complete it without overworking them. The incentive was that those who completed the task got a higher salary, and those who didn't complete would get the normal salary and could also be placed in a job that they were more scientifically fitted to do. Managers looked at each worker as an individual and worked on developing them to the highest state of productivity (Taylor, 2011). Another difference from the division of labor theory, was that the workers would not be limited to one specific type of job, but instead they got the opportunity to learn a variety of work (Taylor, 1914).

In the 1920's a reaction to the concept of Scientific Management theory surfaced, this new management theory, Human Relations, criticized the labor efficiency principles and the workplace Taylor wanted to develop (Miles, 1965; Calhoun, 2002; Bruce & Nyland, 2011). This new theory was created in the aftermath of the Hawthorne experiments by Elton Mayo, who claimed that the experiments demonstrated that economic incentives were inadequate. He argued that most factories were lacking workspace that met the employee's social and emotional needs, which was causing an overall inefficiency. The Human Relations solution to this inefficiency required reversing the severe division of labor, opening for the possibilities of a closer relationship between management and employees and teamwork (Calhoun, 2002). According to Miles (1965), the main goal of the Human Relations solution was to construct a workforce that did not resist formal authority, that cooperates and is ready to work towards finding solutions to organizational problems. Important components to achieve this was acknowledging individual desires and needs, having managers discuss organizational problems with the employees, making employees feel useful and important to the organization.

Dan Ariely (2016), author and Professor of psychology and behavioral economics at Duke University, refers to the view of labor from the industrial-era as one of the problems as to why people are demotivated at work today. In other words, the view that Smith had towards labor is still used in companies today. Ariely has done studies on people's motivations at work, and has found results that do not fit Smith's theory of money being an incentive for people to be more productive. So why is this theory still being used in our society today? Barry Schwartz (2015), psychology Professor at Swarthmore college, says that capitalism was built in Smith's shadow, and that his view of money as an incentive has been passed down from generation to generation, which is why this way of thinking is still present today (Ariely, 2016).

2.2 Productivity

The main focus of the thesis is to examine how the physical work environment affects individual productivity. The definition of productivity is the rate of which output, such as goods or service, are produced compared to the input, such as labor and capital (Hornby, 2010; Heizer & Render, 2014). The focus will be on labor productivity, this to see if individuals get more productive in different environments. The reason for looking at labor productivity, is because the more productive the employees are, the more value is added to the organization (Heizer & Render, 2014).

The concept of productivity, is in this case influenced by the Human Relations perspective, because this perspective emphasizes the employee's needs and desires. Human Relations theory indicates that these variables are closely linked to productivity, and in this thesis, individual well-being is a factor that is assumed to be connected to individual productivity through the physical work environment.

2.3 Well-Being

The concept of well-being has been around for centuries, and economists have tried to measure it in several different ways, like in Adam Smith's *The Wealth of Nations*, where it was suggested that wealth was an indicator of national well-being (Hammond, 2002). This view is not supported by McGregor (2007), he claims that economic growth is not associated with the broader concept of well-being, although economic growth contributes to a certain degree of well-being, such as bringing a nation out of poverty. He argues that well-being has three basic and interacting dimensions: material, relational and subjective. In this

understanding of the concept, each dimension cannot be considered on its own, to give enough insight into how well an individual is doing in their life. In addition, together all three dimensions contain what is required to create individual well-being, in other words, the individual's well-being emerges from a combination of what they have (material), how they can use it (relational), and how content they are in their lives which is derived from what they have and are able to do (subjective) (McGregor, 2007. Retrieved from Pouw & McGregor, 2016). The concept of happiness that is connected to subjective well-being has met some criticisms from known economists, but at the same time there are supporters of this concept (John & Ormerod, 2007; Layard, 2005. Retrieved from Pouw & McGregor, 2016). Steemers (2015) states that well-being consists of two elements, the first element refers to feeling good, which is based on an individual's feeling of happiness, engagement and curiosity. The second element of well-being is about functioning well, which refers to the individual having a sense of purpose, positive relationships and the feeling of having control over their own life. The well-being aspect of this thesis will be concerned with how satisfied individuals are in the workplace, this including positive emotions.

In a work situation, where people are being managed either in a small or large scale, the employee's well-being is also being managed. Research on the topic of employee well-being suggest that the workforce affects the organization's bottom line, as it is critical when achieving the organization's goals and attaining its mission. When people enjoy their daily work, a high level of well-being can contribute to getting more done, and to be able to work considerably longer hours without becoming drained. Organizations that embrace the opportunity to improve their employees' well-being, creates additional engaging places to work. The most progressive leaders use the constant focus on improving employee well-being as a competitive advantage to recruit and retain employees for their business (Rath & Harter, 2010).

2.3.1   Positive Emotion

The term emotion is defined as "any short-term evaluation, affective, intentional, psychological state, including happiness, sadness, disgust, and other feelings" (Colman, 2016. DOI:10.1093/acref/9780199657681.001.0001).

Research has shown that organizations are infused with emotions, which can be used to mobilize resources and create positive energy that can lead to a more productive job performance (Linley et al., 2010. Retrieved from Mikkelsen & Laudal, 2016). These positive emotions are a precondition for organizations to be able to function. To be able to make emotions become positive, the organizations should focus on the term "positive psychology". This term refers to the organization focusing on people, their well-being, and how to get people into a positive state of mind (Mikkelsen & Laudal, 2016). Organizations often tend to focus on the negative aspects of humans, like their weaknesses and vulnerabilities (Luthans, 2002). This is despite that positive emotions being recognized as important in theories of organizational behaviors, and it has been concluded that there is a relationship between employee's emotions and job performance. There has also been established some validity to the claim that employees that are happy and optimistic are more productive at work (Luthans, 2002).

2.4 Motivation

Motivation has become an important element in trying to gain organizational competitiveness (Law, 2016), and an assumption in this thesis is that well-being and motivation are connected, the belief is that a highly-motivated individual also possesses the emotion of well-being.

Motivation is a collective term for a mental process that induces and controls the behavior of individuals (Law, 2016; Mikkelsen, 2016). Maslow (1943) made a framework for human motivation which includes a hierarchy of basic needs that are considered to be motivating factors. The hierarchy consists of five factors, that are all connected and the process starts with the most important one. The first factor is based on basic physiological needs such as food or sleep, the second step is the need to feel safe. From there it is the need for love; the need for caring relation with other people on a general basis; the need for esteem, feeling confident, strong, worth something, capable, useful and necessary; the last factor is self-actualization, this is when a person has the need to become everything that it can become, like

7

a musician making music. The step that a person is on will always be the center, and the need to achieve the factor dominates the mind and organizes the behavior of the person, the needs that are lower in the hierarchy get minimized or forgotten, because needs that are fulfilled are not active motivators. In the "Dictionary of Business and Management 6. Ed." (2016), motivation is related to words including, recognition, need, achievement and desire. Which shows that motivation is still connected to the two highest steps in Maslow's hierarchy. The hierarchy and the definition from the Dictionary of Business and Management, indicate that motivation is connected to an individual's emotions, and therefore is a part of a person's well-being.

Employees that experience low motivation have a higher chance of having low productivity, more absence from work, and negative attitudes (Mikkelsen & Laudal, 2016). This indicates that motivation and well-being are connected, and therefore motivation is an important part of this thesis as it aims to show that individual well-being and productivity are linked. There are two types of motivation that frequently interact; intrinsic and extrinsic motivation (Law, 2016). Here, the focus will be on intrinsic motivation, which is connected to the joy of the job, psychological needs and inner drive to grow (Mikkelsen & Laudal, 2016). The reason extrinsic motivation is excluded from this thesis, is because it could influence the results of the pilot-exercise, which would make it harder to uncover if it is the physical work environment that impact the results, or if it is other external factors.

2.4.1 Self-Determination Theory

Above it was established that there is a link between motivation and well-being, therefore looking at the Self-determination theory (STD) will give a better insight in how these factors are connected and why the study focuses on intrinsic motivation.

Self-determination theory is a theory that focuses on human motivation, development, and well-being (Deci & Ryan, 2008). There are three inherent psychological needs that individuals have that enhance self-motivation and mental health if fulfilled, if not fulfilled it leads to decreased motivation and well-being. These three needs are; competence, autonomy, and relatedness, these factors are essential to facilitate growth, integration, social development and well-being (Ryan & Deci, 1985. Retrieved from Ryan & Deci, 2000). Rather than looking at quantity, this theory looks at types of motivation, with special focus on; autonomous

motivation, controlled motivation, and amotivation. These different types of motivation are used to forecast outcomes of performance, relations and well-being (Deci & Ryan, 2008).

STD splits motivation into intrinsic and extrinsic motivation. Intrinsic motivation reflects human nature's potential for positivity (Ryan & Deci, 2000), were a person does something because of genuine enjoyment for the task, where thoughts of other types of rewards are not present. Autonomy is an intrinsic motivation; this type of motivation affects the developmental path a person chooses. Employees with a high degree of autonomy use more time and energy at solving tasks, and they also take initiative and responsibility so that the task at hand gets finished (Mikkelsen & Laudal, 2016). Motivation is a key part of individual productivity, as explained by author and psychologist Heidi Grant Halvorson (2011), her studies show that the most profound motivation and personal satisfaction is sprung out from the employee's own goals. When people feel intrinsically motivated they tend to find the job more interesting and work harder. Halvorson describe employees that are intrinsically motivated "...more creative, and process information more deeply. They persist more in face of difficulty. They perform better" (Halvorson, 2011. URL: https://goo.gl/vvkrCH).

Extrinsic motivation in contrast to the intrinsic motivation, is doing an activity to achieve some independent outcome/reward (Ryan & Deci, 2000), and the rewards can be, salary, benefits, status/titles, or some other form of recognition (Mikkelsen & Laudal, 2016). This type of motivation is what Deci and Ryan (2008) call controlled motivation, meaning that the behavior of the employees is based on external limitations and control (Mikkelsen & Laudal, 2016). Deci and Ryan (2008), also talk about a third type of motivation that STD focuses on, which is the amotivation. This can be explained as not having any motivation at all, a person feels that they can't do anything right, that they are inept, so they lack both the intrinsic and the extrinsic motivation (Mikkelsen & Laudal, 2016).

2.5 The Physical Work Environment

People spend a lot of time at work (Kamarulzaman et.al, 2011), and a healthy workspace can influence both well-being and productivity. However, a study by John Bergs (2002) showed that amongst 20-30% of office buildings in Western Europe and North America are so-called "problem buildings", referring to buildings where 20-30% of workers have health complaints. The majority of these complaints can be traced back to air quality and discomfort in terms of

temperature, in addition to a lot of non-specific health complaints such as headaches, fatigue and eye irritation.

Adrian Leaman (1995), director of research at the Institute of Advanced Architectural Studies at the University of York, wrote an article that dealt with the issue of discontentment of employees concerning the physical work environment at the office, and if it had an effect on the productivity. From surveys, he found that the statistical evidence showed that employees who were unhappy with the environment in the office were more likely to say that they were less productive at work. This included factors like temperature, air quality, noise, and lighting. According to color-expert Kine Angelo from the Norwegian University of Science and Technology, fluorescent lighting is the most common type of lighting used in Norwegian office buildings today, which has an unpleasant effect on employee's eyes. The light in the office never changes its intensity, from a natural standpoint the light should vary, depending on the requirements the eyes have for completing a task. Poor quality lighting can contribute to employee issues like eye irritation, headaches, and concentration problems (Bjørnskau & Norstrøm, 2017).

A large portion of the problems with office buildings can be traced to technical issues, but concepts from the field of psychology can contribute to a deeper understanding of office workers' complaints and their underlying mechanisms. Psychological factors that often may be underestimated in office design is the effects of the environment, stimuli, the need for one's own territory, identity and contact with the outside world. According to John Bergs (2002) a low-quality workplace can contribute to reduced productivity.

2.6 Visual Elements of the Physical Work Environment

There are several factors that impact individuals at work, and from what is said above; psychological factors of the employees should be taken into consideration when designing an office space. In this chapter of the thesis, the historical perspective on office design will be explored, and this will be compared to the demands that the field of office design face today, and how this can impact employee productivity. There will also be presented theory about color and how it can affect individuals.

In the beginning of the 1990's it was predicted that the classical brick-and-mortar buildings would be replaced by virtual workspaces. The argumentation behind this prediction was that virtual reality and cyberspace (van Meel & Vos, 2001) would make it possible to instantaneously be connected to people all over the world, which would make the workspace itself become more irrelevant. However, the prediction did not come true as most people still commute to offices every day, despite having technology that allows for global and immediate communication. In other words, even though most office workers have the possibility of working anywhere, doesn't necessarily mean they want to. This can be explained by the need to participate in knowledge sharing, develop ideas, and stimulate the human mind, which can be especially important in creative industries. Therefore, the quality of the physical workspace is becoming more critical than ever (Ratti & Claudel, 2016). The issue of the physical work environment is not an unfamiliar subject, as early as 1973 Kotler wrote about the importance of enhancing the work environment, and how this was an investment to improve employee productivity.

2.6.1 Historical Perspective on Office Design

Today office design focuses on personal interactions, performance, and innovations, this can be seen in Silicon Valley as *the new way of office design* (Waber et al., 2014). This is not a new concept and was conceived by Allen and Gerstberger in 1970 as a "non-territorial office", which did not include any walls and had no permanent work stations. Instead the office consisted of a variety of desks, workbenches, quiet area, and a silent area where no talking was allowed (Allen & Gerstberger, 1970; Retrieved from van Meel, 2011).

This concept of "non-territorial office" was created in a study conducted on a group of product engineers from IBM, the intention behind the study was to see if the product engineers would start sharing problems and experiences among each other, to ultimately improve and increase the quality of their own work. The idea was that since none of the engineers had a permanent work station, they would be forced to move around which would result in more frequent interaction among co-workers, the desired outcome from this study was improved communication. The experiment was supervised in detail by two researchers, Thomas Allen and Peter Gerstberger, over the course of a full year. The study showed, that the employees' feelings towards a non-territorial office concept was positive, and it also uncovered that the internal communication had improved significantly. Still, Allen and

Gerstberger expressed caution and highlighted that the concept would most likely be more successful with group that spend much of their time out of the office, which was the case for IBM engineers who spend a lot of their time in labs. Moreover, they warned that any extensive use of the concept should be carefully planned as it could aggravate feelings of fear or even panic among those who have not experienced it – an observation that is still valid today. Despite that the "new office" concept was a highly relevant topic of discussion in the seventies, it was by no means mainstream (Allen & Gerstberger, 1970; Retrieved from van Meel, 2011).

"A new way of office design" has become more relevant nowadays (Waber et al., 2014), and one of the most familiar examples are the Google offices. Google office design uses tools as colors, textures, and props such as pool tables and slides to create a new kind of office space (Appendix A). The idea behind this kind of office design is to create a space that triggers the employees thought process, as their employees are paid to spend time on thinking and experimenting. Despite the risk of failing, Google has aimed to create a work environment where mistakes serve as learning, the company not only embraces chaos, but profits from it (Emerald Insight, 2007). Today, managers deal with cognitive enterprise in a world where the transfer of information is up to 10,000 times faster than it was two decades ago. The information communication technology (ICT) has been a large contributor to change the way business works (ibid). The strong integration of technology both at home and in the workplace, has called for new ways of working, and despite the continuous innovations in technology, office workers still spend a considerable amount of time in office buildings. A new generation of employees and new lifestyles also requires other demands in terms of office design, offices should reflect ideas about what kind of organization it is, and opinions about how the work should be performed. These ideas tend to change over time, which is why the idea of what an office should look like also changes. The office building is partly a product of the spirit of the age (van Meel & Vos, 2001).

Workspaces can be designed to produce specific performance outcomes, one space can be designed specifically to increase productivity, while another can be designed for innovation purposes (Waber et al., 2014). This concept has often served as an incentive for corporations to excessively redesign the physical work environment, as it is a simple and practical improvement to carry out. Although the physical work environment can be designed to encourage certain behavior, it cannot be guaranteed that by redesigning the office it will

generate the behavior desired. Workplace design is a somewhat faddish phenomenon, in part because there is little evidence on what specific factors affect a knowledge worker's performance, and how these factors are connected (Davenport, 2005). This thesis will look the effects colors can have on the physical work environment and how it can impact individuals.

2.6.2 Color in The Office Workspace

In addition to giving character to the physical work environment, color serves as a useful tool in influencing e.g. human behavior, decision making and health, whether it is on a conscious or unconscious level (Jalil et al., 2012). It is also an element that can affect employee mood, satisfaction, motivation and performance (Stone, 2001). Colors act as a subtle stimulation with a noticeable impact and is influencing human lives physically, psychologically, physiologically and sociologically. A common understanding of colors is that they are divided into two groups, cool and warm, this refers to the differentiation of its wavelength characteristics. Blue, green and purple are observed as cool colors because of their shorter wavelength compared to warm colors. Taking this into account, colors can still be perceived differently (Jalil et al., 2012). The perception of the different color schemes is contingent on various factors, such as genetics, culture, education and socioeconomic levels (Kamarulzaman et.al, 2011).

Although, there is a possibility that color in the environment indirectly affects a person's mood through influence on arousal and weariness (Stone, 2001). The University of Texas has conducted a series of experiments over the past two decades, which focused on how interior color impacted employee productivity in an office environment. In the study, elements like job satisfaction, task performance and mood when working, were tested when interacting with different interior colors. The researchers found that subjects that worked in light colored offices, such as white, beige, yellow, or grey, made more errors than those in work spaces with darker colors. Interestingly the subjects preferred to work in light colored rooms, and were confident that it would facilitate their work performance. Furthermore, the studies showed that subjects working in dark color offices, such as red, blue green, or purple, were performing better than those in the light color offices (RiosVelasco, 2009). Still, white is the most frequently used color, acting as a neutral background in offices, institutions and homes (Kwallek, et.al., 1997).

Considering that most people spend a lot of time at work, and characteristics of the physical work environment has an impact on their perceptions, productivity and behavior. This thesis seeks to investigate the use of color as part of the physical work environment, and what effects it might have on employee productivity. Although, there is little empirical evidence that supports the idea that color impacts individual productivity and well-being. Nevertheless, Elliot et al. (2007) writes about how motivated behavior is produced from color stimuli by having the color evoke an evaluation process, this process occurs without the individual's awareness or intent, the impact of the color is naturally unconscious. Kamarulzaman (2011) states that a person's mood is also affected by color, and that having the "right" colors in the workplace is beneficial to keep the employees in a good mood, which then again can motivate them to be more productive. Having the "wrong" colors might have a negative impact on the employees, which consequentially can raise their experience of stress, depression or boredom in the workplace.

When looking at what colors are appropriate for an office workspace, one needs to take color perception into consideration. An article from 1978 by Cimbalo et al., explains the results of an experiment conducted on a group of American University students and on a group of children with the mean age of 3,7 years, on how they perceive different colors. What they found was that although in quite different stages in life, colors were still experienced in the same way, the results demonstrated that there was a strong and reliable relation between emotion and color. In these studies, colors like, red, brown and black were selected as sad colors, and yellow, orange, green, and blue were recognized as happy colors. Goldstein's research showed that the color red increases human receptiveness to external stimuli and leads to a state of excitement, which has an effect on the human motor and emotional response (Kwallek et.al, 2007). Stone (2001) also talks about how red appears to be a stimulating color, but she also includes yellow in this category. Looking further into the effects of darker colors, Elliot et.al (2007) conducted several studies on how red can lead to performance attainment. Their hypothesis assumed that red is associated with the psychological danger and failure, and that it would therefore encourage the subject to perform better. The studies showed that using red in a work environment would impair the subject's rather than enhance it.

Colors with a longer wavelength appear to create stronger associations to negative emotions, compared to colors with shorter wavelength. In a study of ninety-eight college students from

the University of Mannheim on how they responded emotionally to different colors, it was discovered that blue evoked a high number of positive emotional responses with the students, this included feelings of relaxation, happiness, calmness, peace, hope, and comfort. The results also showed that blue could be associated with negative emotions such as sadness and depression, as some students associated blue with night and dark skies (Kaya, 2004). There has also been found evidence of blue and green having a calming effect on people (Stone, 2001) and in general, across cultures, blue has proved to be the favored color (Singh, 2006). Researchers Kamaruzzaman and Zawawi (2010) also concluded on that the blue color has the most arousal effects and the highest rating for a performing environment (Retrieved from: Jalil et al., 2012).

2.7 Hypothesis

In the research question the term "physical work environment" is used, this does not mean that the color aspect this thesis looks at, can be applied to all work settings. Situations where it would be relevant is in the case of "knowledge workers", the term originates from author and management consultant Peter Drucker's book *The Age of Discontinuity* from 1969 (Rosen, 2011). The knowledge workers are employees that analyzes and communicates information, use prominent reasoning and systematic thinking, and are particularly creative in their output (Law, 2016; Heery & Noon, 2008). Some knowledge working jobs, such as accounting, auditing, and telemarketing, are predicted to become much more automated within the next two decades (The Economist, 2014). However, it seems that the term "knowledge worker" is still evolving by making a shift from knowledge towards learning, because in today's complex and ever-changing environment employees need to be able to learn (Emerald Insight, 2016), adjust, and implement their learning abilities to new circumstances (Morgan, 2016). The color in the physical work environment would in this setting help to stimulate the knowledge worker's creativity (Dul et al., 2011). The thesis includes a well-being perspective that is connected to individual productivity, so the color aspect could also be relevant for work done in an office setting, which includes technical, management, clerical and administrative work (Heery & Noon, 2008, Law, 2016).

This leads to the hypothesis for the pilot-exercise:

Color affects individual productivity.

The pilot-exercises will be used to explore how this hypothesis can be tested on a bigger scale, where two colors will be examined. The first color is white, this is because it is often used as backgrounds in office buildings (Kwallek, et.al., 1997). This is possibly because work environments contain a variety of different people, and white is often viewed as a non-dominant color and therefore "safe" (van der Voordt et al., 2017). The second color that will be applied is blue, this color is often associated with elements from nature, the ocean and sky, and is linked to the qualities of openness and peacefulness (Mehta & Zhu, 2009), it is also regarded as a color that is favored when it comes to making a relaxing atmosphere (Mahnke, 1996. Retrieved from van der Voordt et al., 2017). Based on the assumption made in this thesis, that productivity might be indirectly affected by well-being, is the reason for the choice of colors used in the pilot-exercise, because of the attributes that they in theory contain.

3.0 Method

The thesis seeks to investigate the connection between color in the physical work environment, and the effect it can have on individual productivity and well-being. Examining the hypothesis requires a larger-scale study to see if the results have any significance, because of time constraint and a small sample, this thesis conducts a pilot-exercise to gain knowledge on how to conduct a larger-scale study. The pilot-exercise will consist of a pilot-experiment and a follow up pilot-questionnaire, there will also be observations included as a supplementary tool.

3.1 Design of Pilot-Exercise

The objective of the pilot-exercise is to test the hypothesis and provide learning points that can be used in a full-scale study. There has previously been done research on the connection between the physical work environment and productivity, but the focus of those studies has mainly centered around office layout, air quality, temperature, lighting and noise (Kamarulzaman et.al, 2011). The color aspect of the thesis stems from theories on how color affects an individual's mood and emotions. There has been carried out some research on color-use in the environment and productivity, where evidence suggest that there might be a connection between color in the work environment and mood (Stone, 2001). The assumption is that having the "right" color in a work environment will affect a person's mood and motivation, and consequently increase individual productivity. The research design that will be used is a *causal design* (Gripsrud, et al., 2010), which examines if there is a relationship between variables, where a change in one variable is created by an alteration in the other variable (Duignan, 2016).

The pilot-exercise has an experimental approach, where a controlled variable will be manipulated as a part of the research plan, and quantitative measurements are utilized to evaluate the effect on variables that are of interest in the pilot-exercise (Courtney, 2017). Using a quantitative approach and analysis of differences, a pilot experiment and questionnaire will be conducted to collect the data. The quantitative data collected will be analyzed in the statistical program, Stata. Knowing that the sample in the pilot-exercise is too small to conclude whether the hypothesis should be rejected or not, the pilot-exercise is supposed to be a foundation for a larger-scale study and therefore the results will be statistically tested as it would in a full-scale study. To observe whether there is a significant

17

difference between the two averages of the variable, an independent samples t-test is applied (Duignan, 2016). The independent variable in the pilot-exercise is color, and the dependent variables will be productivity and the well-being aspect (Courtney, 2017).

3.2 Testing of the Hypothesis

A hypothesis is an assumption about a relationship or differences between variables, which is then tested with a scientific method that evaluates if the relationship or difference has emerged accidentally, or if the difference is statistically significant (Duignan, 2016). In this thesis, there will be conducted a pilot-exercise containing a pilot experiment and questionnaire to collect the data needed to assess the assumption that color affects individual productivity. This assumption is tested using a pilot-experiment, where the participants are asked to perform a task in a room where the color has been manipulated. The pilot-questionnaire is used to collect data on the respondent's well-being and motivation in retrospect of the pilot-experiment. This is then again, used to evaluate whether the respondents have had different experiences of well-being and motivation depending on which room they were assigned to. The purpose of having both the pilot experiment and questionnaire, is to examine if the room with the highest individual productivity score also is the one with the strongest perception of well-being. As this is a pilot-exercise, it needs to be pointed out that the results obtained cannot dismiss the thesis' hypothesis, but rather examine the feasibility of the intended approach that will be presented below (Leon et al., 2011. Retrieved from Hazzi & Maldaon, 2015).

3.2.1 Pilot-Exercise

In this thesis, a pilot-exercise is used with the purpose of acquiring knowledge to further develop an experiment on a larger scale (De nasjonale forskningsetiske komiteene, 2010). In other words, the pilot-exercise is performed as a small-scale construction, or trial run, which serves as a preparation for a full-scale study (Polit et al., 2001. Retrieved van Teijlingen & Hundley, 2001). Conducting a pilot-exercise gives the advantage of uncovering potential aspects where the main research project could fail, which for instance could be if the suggested methods turns out to be inappropriate or too complex, or where research protocols may not be followed (van Teijlingen & Hundley, 2001).

When conducting a pilot-exercise, it has been suggested that it should not be a hypothesis testing study, as these calculations would require a larger sample size than the one used in this study, and the analysis should suggestively be descriptive (Jones et al., 2017). The main purpose of the pilot-exercise in this thesis is to assess the feasibility of conducting a full-scale study on how the use of color can affect individual productivity in the workplace, and examine whether there is a relationship between the levels of individual well-being and productivity.

3.2.2 Design of Pilot-Experiment

The pilot-experiment conducted in this thesis is made as realistic as possible to see if this could work in a larger setting. The pilot-exercise seeks to detect if there is a possibility of there being a cause and effect relationship between two variables, this is classified as a "classical experiment". Here the independent variable is manipulated, and any change in the dependent variable is systematically detected. These types of studies are normally related to laboratory conditions (Duignan, 2016) that takes place in an artificial environment (Gripsrud, et al., 2010).

The pilot-exercise will be conducted using a sample of students from the University of Stavanger, where the randomization of the sample occurs by not determining what room each of the participants will be placed in beforehand (Johannessen, et al., 2011). The pilot-exercise will be conducted in two identical rooms at campus, in the Arne Rettedal's building. The rooms had two windows overlooking a hallway and cafeteria, to make sure that the participants did not get distracted or disturbed during the pilot-exercise and to keep the manipulations a secret, the windows were covered with white paper cloth. To make sure that the rooms still got some natural lighting the windows were only partially covered, the windows were tall enough that the top did not require to be covered, and still be able to keep the rooms secret (Appendix B).

The manipulation was done in exactly the same way in both rooms, only with different colors. The walls were white, and the floors and doors were grey with a hint of blue. There was one desk and chair in each room, where the desk was covered with a cotton table cloth and the chair with a fleece blanket, and on the floors a round rug was placed in eyesight of the participant. There were some restrictions when it came to the rooms, this made it difficult to

make a subtle manipulation for the pilot-exercise. Instead it was decided that the manipulation would be evident, since any changes to the rooms would be obvious for the participants anyway, the interior items were then used to enhance the colors in the rooms. This kind of situation where changes in behavior and performance are a result of the participants knowing that they are a part of an experimental study is called the "Hawthorne effect" (Campbell et al., 1995). The idea is that a participant's behavior and performance during an experiment, is altered by knowing that they are being observed (Jones, 1992; Campbell et al., 1995). This effect of increased individual productivity when the participants know they are participating in a study, has also been explained by psychological stimulus, where the participants perceive that they are being singled out and therefore feel important (Parsons, 1974).

The pilot-exercise does not require any prior knowledge, and all information about the execution of the task was given before the participants went ahead with completing it. The task that was used was a trigram puzzle from the game Ubongo, the tile consists of a white area that can be covered by using four puzzle pieces, and on each tile, there is an overview of six different ways to cover this area to solve the task. In all, there are twelve different puzzle pieces, where it is only allowed to use four specific pieces at a time, and the overview on the tile shows which pieces the participants can use to complete the task. To measure the productivity, the point is to see how many tasks the participants can complete. If the participant completes all six tasks on one tile, they move on to a new tile where the white area is shaped differently, they then keep on solving as many tasks as they can on the new tile until the time is up.

The participants have twelve minutes to complete as many tasks as they can. The twelve minutes were calculated from the original game, where the players have two minutes to complete one task on a tile, and since there are six tasks on one tile, it was decided that the participants would have twelve minutes to complete as many tasks as possible. Twelve minutes is a short amount of time to use on a study like this, but since this is a pilot-exercise having a longer time-aspect was not imperative, as there were time-constraints when conducting it.

The rules on how to complete the task will be explained before the participants start working on it, and it will be made sure that there are no misunderstandings on how to execute the task. While the participants work on solving the task there will be an observer present in the room,

to make sure that there is no cheating, when a participant is done with one task they need to give a verbal sign so that the observer can check and give the go-ahead to continue. While the observers will be in the rooms to register the amount of tasks completed, they will take measures to try and not make the participants insecure about having someone present while completing the task, this includes the observer facing away from the participant.

There will not be given any information about the pilot-exercise beforehand, other than the approximate time it will take to complete and that there is no prior knowledge needed to participate. It is important that the pilot-exercise is held confidential throughout the week it is being conducted, so the participants won't have any exterior motivation, and that the variables affecting the results are not from an outside source. Any information and observation regarding the rooms, task and questions will be urged to be kept confidential by the participants until the pilot-exercise is complete. No information about what is being tested will be given to anyone besides the observers while the pilot-exercise is being conducted.

3.2.3 Design of Pilot-Questionnaire

When using questionnaires as a research method, it is preferable to use questions from questionnaires that are already constructed, as these often have undergone validity and reliability tests (Johannessen et al., 2011). Seeing that this is a pilot-exercise with a short timeframe, it was decided to use a small self-made questionnaire that was constructed according to guidelines from methodology books. On a larger scale, it would be advantageous to use questions from other surveys that have already been validated.

In the Oxford Dictionary of Business Research Methods (Duignan, 2016), questionnaires are defined as a research tool, which consists of a series of questions that provides a structure for producing the research material that is needed for an analysis. In the pilot-exercise the data for the well-being aspect of the thesis will be obtained by a series of self-made questions, which the participants must answer after completing the pilot-experiment. It will consist of ten questions, where eight of them are used to collect the relevant data, one is about gender, and the last one is a control question to make sure that those who participated are students at the University of Stavanger.

The questionnaire consists of what is called fixed questions and answer alternatives, this provides a questionnaire that is pre-coded. Using a pre-coded questionnaire makes it easier to standardize the responses from the participants, making it less complicated to discover similarities and differences in the answers. The downside is that it is not possible to gather additional information not included in the questionnaire (Johannessen et al., 2011).

The construction of the pilot-questionnaire was done according to guidelines in the book by Johannessen et al. (2011) "Forskningsmetode: For økonomi og administrative fag". Even though this was only a questionnaire for a pilot-exercise, getting the right perception from the participants was desired, this could be accomplished by using a scale with multiple alternatives, minimum of five. A challenging element was settling on what kind of scale to use, like if the scale should contain a neutral answer alternative such as "do not know" or "do not want to answer". The option of a neutral answer can be a way of minimizing a source of error, as the participants are not forced to choose an answer that does not fit them or not answer at all (Johannessen et al., 2011). The pilot-questionnaire ended up with six answer alternatives to each question, none had a neutral alternative. This decision was based on the need to know in which direction the participants lean towards when it comes to the experience they had when completing the task. This gives a better possibility of assessing how they felt when participating in the pilot-exercise.

An aspect that might become a source of error is the need to be socially accepted, meaning that some people might choose to alter their answers to better fit with what is socially acceptable (Johannessen et al., 2016). To try and avoid a situation like this, the questions were undemanding to answer and non-intrusive. The questions are about the participant's perception on their own efforts when working on the task they were given. The pilot-questionnaire was anonymous; the participants answer the questions without having anyone in the room with them. The pilot-questionnaires will be put in a box so that there is no way of identifying who answered what, and there are no personal questions. There are still several sources of error that can affect the answers, since using this type of method to gather data does not automatically give more genuine information than other methods of collecting data (Johannessen et al., 2011). The pilot-questionnaire can be found in Appendix C.

3.2.4 Observation

As a rule, the method of observations is mostly used in recording or measuring behaviors of individuals. This can be done in both a controlled and uncontrolled environment (Duignan, 2016; Gripsrud et al., 2010). The pilot-exercise will be conducted in a controlled environment where a person will be in the room when the participants complete the task. This is used as an additional tool along with the pilot experiment and questionnaire. By monitoring the participant's behavior in the pilot-exercise it is possible see if there are any learning points that would be wise to include when executing this on a larger scale. Another reason for having a person inside the rooms is to make sure that there is no cheating, so that the individual productivity measures will be correct.

3.2.5 Pre-Testing the Pilot-Exercise

It was decided to have a pre-test of the pilot experiment and questionnaire. When it comes to questionnaires, pre-testing is useful to reveal any confusions or if there is something missing (Gripsrud et al., 2010). This gives the opportunity to change the questionnaire and improve it before using it in the pilot-exercise. The pilot-experiment also needed to be pre-tested, because there were some variables that needed to be settled, like seeing how individuals acted when having twelve minutes to solve the task. The trigram puzzle that was going to be used in the pilot-experiment had two degrees of difficulty, pre-testing this gave the possibility of seeing how hard the two degrees were perceived, and decide which of the two to use. Receiving feedback on the explanations on how to execute the task, given before the participants tackled the it, would also give an indication on how this could be improved.

For a pre-test, there should be at least a sample of 4-5 people to undergo the test and give feedback, it is also preferable that these persons have the same qualities as the sample for the pilot-exercise (Johannessen et al., 2016). The sample for the pre-test were eight University students, originally there were supposed to be ten participants but two had to cancel. The questions that got pre-tested had five answer alternatives, with the possibility of a neutral answer. The feedback about the questions was that they were straightforward, easy to understand and answer. When going through the questions afterwards it was discovered that having a neutral answer was not optimal for the pilot-exercise, as it was more beneficial to know what direction the participants were leaning towards when it came to comfort levels and such. The answer alternatives were changed and included six answer alternatives instead of

five. In the pilot-exercise, the participants would have to give an indication on how they perceived the task and how they were feeling when solving it.

When pre-testing for the pilot-experiment, the plan was to have at least five participants for each degree of difficulty on the trigram puzzle, but ended up with four instead. The reason for wanting ten participants was to make sure that there was enough information to decide the degree of difficulty. However, having four people on each difficulty gave a good enough indication on which one to use. The feedback from this part of the pre-test was that the task was fun and that the explanations on how to execute the task were good. It was observed that the first degree of difficulty was too easy, which lead to the decision to use the second difficulty for the pilot-exercise.

3.3 Sample

The target group used in the pilot-exercise were students at the University of Stavanger, the sample was strategically selected, since getting a random sample when working with quantitative analysis is not always easy. The pilot-exercise includes a pilot-experiment, where it will be random which color room the participants will be put in, which would make this a randomized controlled trial (Johannessen et al., 2011). Students are frequently used as subjects for research, even though using students as a representation for a larger population has received much criticism. The criticism originates from its links to ethical issues concerning voluntariness or coercion, privacy, and reward policies (Leentjens & Levenson, 2013). Although these are genuine concerns regarding research in general, Libby et al. (2002) points out that using students as research subjects is fully appropriate in studies that focus on general cognitive abilities or individual reactions, because the knowledge needed is expected to be learned in the setting of the experiment (Liyanarachchi, 2002). The pilot-exercise in this thesis looks to observe the performance of the participants, and register how they evaluate their own performance and attitude towards the pilot-exercise. Neither the task or questions require any prerequisites, and the focus of the pilot-exercise is mainly on the participant's cognitive abilities and performance, which supports the argument made by Libby et al. (2002) for using students as research subjects.

The participants had to agree to be manipulated in a controlled environment (Druckman & Kam, 2009). For practical reasons, using students from the University of Stavanger would

make the recruitment process easier, it would be possible to market the enrollment for student participation in the pilot-exercise on social media as well as to students at campus. The pilot-exercise was conveniently set in one of the University buildings, the ambition for the strategic selection was to gather an expedient group of participants, rather than a representative one. This because the qualitative nature of the pilot-exercise focuses on gaining more knowledge on the subject researched rather than make statistical generalizations (Johannessen et al., 2011). The pilot-exercise included 30 participants in total, meaning there were 15 students in each room.

3.4 Data Analysis

Before conducting a statistical test on the data from the pilot-exercise, validity and reliability needs to be reviewed. When conducting the test on a bigger scale, both validity and reliability need to be tested, doing this will make sure that the data collected is reliable and therefore is possible to make inferences from (Duignan, 2016).

For the pilot-experiment, internal and external validity will be examined. The internal validity focuses on the relationship between cause and effect, if it is the variable that is supposed to affect the data that is causing the results, or if there is an external variable affecting the data. The external validity is about generalizing the results, meaning to what degree the results can be transferred to similar situations (Gripsrud et al., 2010). Because this is a pilot-exercise for a larger experiment, the reliability will consist of a discussion on the execution of the pilot-experiment, and if the procedure would give essentially the same results and conclusions if others tried to work on the same research question or problem (Duignan, 2016).

The questionnaire in the pilot-exercise contained a few self-made questions, and to show the validity of the questions, face validity will be used. This is the simplest form of validity that expresses in a subjective manner what the questions seem to measure (Gripsrud et al., 2010). To test the reliability of the questionnaire, it will be used a statistical test called Cronbach's alpha, this test measures the reliability and internal consistency of the data collected from the questions (Duignan, 2016; Elliot et.al, 2016). Cronbach's alpha looks at the averages between the components and the quantity of items in the scale, where each item should provide exclusive information, and at the same time be connected to the other components (Duignan,

2016). Testing the reliability of the questionnaire indicates how exact and reliable the data collected is (Johannessen et al., 2016).

To test the data in the pilot-exercise, a two independent samples t-test will be used. A t-test for two independent samples is designed to compare means of same variable between two groups. Here the data from the trigram puzzle tasks between the two rooms are going to be compared, as well as all the answer alternatives from the pilot-questionnaire. The t-test examines if the differences between the two rooms are representative or if it is a statistical fluke (Burin, 2006).

Going through with analyzing the data from the pilot-exercise is conducted to show how this could be done when conducting a larger-scale study, also to gain experience and learning how to work with statistical tools and analyzing the results. There will be presented some learning points as well, as the execution of the pilot-exercise was done to get a better understanding of how a larger-scale study with this type of method would have been carried out.

4.0 Analysis and Results

The statistical analyses presented in this chapter are conducted on the data collected in the pilot-exercise, but the sample used is too small to produce any significant results when it comes to the differences between the rooms. The pilot-exercise can be applied as learning points, that can be used for a larger-scale study. Prior to the presentation of the results, the reliability and validity for the pilot experiment and questionnaire will be presented.

4.1 Validity and Reliability

Data is not the reality, but just a representation of it. Therefore, it is important to find out how relevant the data is, this is where validity comes in, because it is important to know if what was meant to be measured, is what has actually been measured (Johannessen et al., 2016; Gripsrud et al., 2010). Reliability is about making sure that the results are reliable, in other words, if the study would be conducted again, one would expect that similar results would be generated (Gripsrud et al., 2010).

4.1.1 Pilot-Experiment

Validity

This pilot-exercise was conducted in an artificial environment, laboratory conditions, meaning that the internal validity might be strong since the possibility of controlling the environment and other stimulus is easier (Gripsrud et al., 2010). By using laboratory conditions, it makes it more straightforward to establish with a degree of certainty, that any change in the dependent variable is due to the alteration in the independent variable or other confounding variables. Confounding variables are variables not included in the pilot-exercise, this can be due to them being unknown, or they might not have been considered as relevant (Duignan, 2016). Having a pilot-experiment with laboratory conditions is advantageous because it gives higher internal validity (Gripsrud et al., 2010), meaning that the pilot-experiment can with some certainty, conclude that it measure what it intended to measure. Although there are confounding variables like mood, shape, hunger, etc. that the participants might be experiencing, which is not possible to control, this might have affected the results. In the pilot-exercise the "Hawthorne effect" was included, this is an intentional factor which makes the results different from what they would have been in a more natural setting (Gripsrud et al., 2010).

Because the pilot-experiment is related to laboratory conditions it can be difficult to generalize the results, this because of the controlled environment, which can lead to a low external validity (Gripsrud et al., 2010). It is arguable that there is some degree of external validity, because the pilot-exercise is conducted in an environment where the sample is accustomed to work. The sample consists of University students, the environment is rooms at campus that are available for students to study in, the design of these rooms is not too different from office spaces, regarding the simplicity and colors. It can be argued that to some degree it would be possible to generalize the results from the pilot-exercise, and therefore there would be some extent of external validity present.

Reliability

A pilot-experiment was used to measure the individual productivity of the two different colored rooms. The reliability for an experimental method, is concerned with to which extent the same results will repeat itself if the study is conducted several times (Gripsrud et al., 2010). The design of the pilot-experiment conducted in this study was simple, using two identical rooms and a trigram puzzle. When it comes to the reliability, the pilot-experiment is easy to reconstruct, arguably if someone duplicated this design, they would end up with similar results. The intention of using a pilot-experiment is to see if it is possible to construct it as a larger-scale study, and having a reliable pilot-experiment is preferable as this is required in a full-scale study.

4.1.2 Pilot-Questionnaire

Validity

The pilot-questionnaire (Appendix C) is a supplement to the pilot-experiment, and is used to see if there are differences between the two rooms in terms of individual well-being of the participants. To check the validity of the questions, a factor analysis was considered. However, because of the limitations related to the pilot-exercise, such as the small sample size and the limited amount of questions, a factor analysis was considered to not be necessary. Although in a large-scale study, it would be advantageous to include a factor analysis to analyze the validity of the questions.

Alternatively, *face validity* can be used, this type of validity is based on a subjective evaluation. Face validity was used in this thesis, and it will be argued why the questions used

in this pilot-exercise measure what they are supposed to measure (Gripsrud et al., 2010; Elliot et.al, 2016). The pilot-questionnaire is supposed to measure the individual well-being and motivation experienced by the participants, and was constructed in a way that there was no previous knowledge needed to answer the questions. The questions were self-made, with the use of methodological theory to ensure that the questions and answer alternatives were developed in a correct manner. To make sure that the answers from the participants were as truthful as possible, the pilot-questionnaire was anonymous and the participants were alone in the room when answering. Each question, apart from the two control questions, used a scale with six pre-defined alternatives that would serve as an indication on whether the participant's experience was positive or negative.

There were eight questions in the pilot-questionnaire with a similar layout, with the purpose of measuring individual well-being and motivation. In the next two sections the thoughts behind the questions will be presented, starting with the questions regarding well-being and continuing with the questions concerning motivation. Subsequently, there will be provided a summary on why the questions are valid.

Well-being

The first question was divided into three parts, a, b and c, which was supposed to measure well-being on an unconscious level. The three parts had six answer alternatives that ranged from different stages of positive emotions to different stages of negative emotions. These questions were used to get an insight into possible differences of emotions between the two rooms.

Question six is more of a direct question about the comfort level experienced in the room, where the participants needed to reflect upon the physical work environment they were in. There were six answer alternatives that ranged from very comfortable to very uncomfortable.

Motivation

There are four questions that are concerned with motivation, these are all connected and concerning how the participants experience solving the task and their own efforts. These questions were included as the results could give an indication on the emotions of the participants, and when viewed in context with the well-being questions, could give an

indication on if a room with more perceived well-being also consisted of higher levels of motivation.

Why are the questions valid?

When working with humans there are factors that are not possible to control, and that can affect the result, this can include factors like mood, hunger etc. Measuring emotions is complex, but here the interests was in the participant's perception of what they experienced when working on solving the task. The questions gave an indication on how the participants were feeling, and how the they perceived their own effort and performance. The data provided from the questions could be used to compare the well-being aspect of the pilot-exercise, which was the main reason for developing the pilot-questionnaire. Because of this, arguably there is some validity in the questions.

Reliability

To test the reliability of the pilot-questionnaire, there was conducted a Cronbach's alpha analysis in the statistical program Stata. If a questionnaire is to be defined as acceptable, the value from this test needs to be 0.70 or higher (Duignan, 2016). The results showed that the alpha was at 0.7904, and therefore it can be concluded that the questions used had an acceptable amount of reliability (Appendix D).

4.2 T-Test for the Pilot-Experiment

The pilot-experiment was constructed to see if the participants in the blue room performed better than the ones in the white room. The two independent samples t-test is designed to compare means of the same variable between two groups, the test uncovers whether the difference between the two rooms are representative or a random coincidence (Burin, 2006). Here the means of the completed trigram puzzles is compared between the two groups, in this case the colored rooms.

The variable for the blue room is coded as 1, while the white room is coded as 0. The t-test presented below is performed with a 95% confidence interval.

```
Two-sample t test with equal variances

    Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
----------+--------------------------------------------------------------------
        0 |      15    9.333333    1.119807    4.336995    6.931586    11.73508
        1 |      15    10.06667    1.360905    5.270764    7.147815    12.98552
----------+--------------------------------------------------------------------
 combined |      30         9.7    .8685435    4.757209    7.923629    11.47637
----------+--------------------------------------------------------------------
     diff |            -.7333333    1.762394               -4.343433    2.876767
--------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   -0.4161
Ho: diff = 0                                    degrees of freedom =        28

    Ha: diff < 0                 Ha: diff != 0                  Ha: diff > 0
 Pr(T < t) = 0.3403       Pr(|T| > |t|) = 0.6805          Pr(T > t) = 0.6597
```

Figure 1.

With regards to the pilot-experiment only having 30 respondents in total, the results showed no significant results. However, the mean number of completed trigram puzzle tasks (productivity) appeared to be slightly larger in the blue room. The mean of the trigram puzzle tasks completed in the blue room is 10.07, while its 9.33 in the white room, which is not large enough for a significant difference between the two rooms. The p-value in this test is 0.6597, which in this case the hypothesis of this thesis is not supported, therefore it is not possible to conclude that there is any difference in productivity between the rooms. The results from this analysis was expected, as this is a pilot-experiment and the sample was small, and this analysis only demonstrates how a statistical test could be carried out on a larger sample if a full-study was conducted.

4.3 T-tests for the Pilot-Questionnaire

The two-samples t-test was conducted on the eight questions from the pilot-questionnaire that was designed to measure individual well-being. The results from these tests are presented in Appendix E. The means from the t-tests appear to be slightly higher in the blue room, except for question four. The remaining seven questions point towards a more negative result on individual well-being compared to the means in the white room. Considering that the t-tests did not show any significant differences it can be assumed that this might be a coincidence. This was a pilot-questionnaire, the sample size was too small to provide a conclusion on whether the hypothesis is true or not, but the pilot-questionnaire still gives an indication on how the statistical testing could be performed in a larger-scale study. In other words, the results from the t-tests done on the questions showed no significant differences between the two rooms.

4.4 Learning Points

The reason for conducting a pilot-exercise was to gain knowledge on how it would be possible to carry out a full-scale study on the subject for this thesis. This part of the analysis chapter are results from what has been learned during the execution of the pilot-exercise.

Time aspect, this learning point can be divided into two sections:
1. The time aspect when completing the task. Having only twelve minutes to work on solving the task is too short. In a larger-scale study, having more time to complete the task will make it easier to get data that is more reliable, and it would be a higher possibility of discovering if there are any significant differences between the two rooms.
2. The time aspect of conducting the pilot-exercise. The rooms that were used in the pilot-exercise were only available for a week, which is too short of a timeframe for a full-scale study. On a larger-scale, the study would have needed to be conducted over several months. This would make error variables smaller, and the data collected would give a much stronger indication on significance levels, and if the hypothesis could be rejected or not.

Color, in the pilot-exercise only two colors were tested, blue and white. Conducting a full-scale study on the hypothesis in this thesis, would require more colors to be compared to the white, since the hypothesis states that color affects individual productivity. This would give a deeper understanding of how different colors impact individual productivity, compared to the neutral color white. Furthermore, there may be other colors that can have a significant impact on both individual well-being and productivity.

Other factors, there are several factors that can impact an individual in the physical work environment. In the pilot-exercise only one of many factors were looked at, color. In a larger-scale study factors like lighting, noise and air quality is some of the factors that would be useful to include, as these might affect both individual productivity and well-being of an individual.

Observation, having a person in the room while the participant was solving the task, was not an optimal solution. The observer might have affected the participant's experience of the pilot-exercise negatively, seeing as some of the participants felt the need to talk to the observer during the pilot-exercise. Some participants were continuously pointing out how poorly they felt about their own performance and/or questioning why they hadn't been able to solve the trigram puzzle faster, which might have indicated that they felt uncomfortable about the monitoring in the room. The observer was not allowed to keep a conversation with the participant, and could consequently not answer any remarks that were unrelated to the practical execution, as it was important for the results that the observer's behavior was similar with all the participants. In the larger-scale study, the participants should not be monitored by a person in the room, but rather find a solution to registering the productivity level without being physically present in the room.

Manipulation, the manipulation made in the pilot-exercise was intentionally made ostentatious, as the participants would notice any change to the environment even if trying to make it subtle. The room was clearly manipulated with color, which the participants noticed. When conducting a full-scale study, it would be preferable that the experiment was conducted in an environment where the manipulations seems more natural, this to get a more realistic result and minimize the Hawthorne effect.

The questions, having a questionnaire that is compiled by questions that have been used in previous studies, and have been tested for validity and reliability, would be beneficial to use in a larger-scale study. This is because these questions are specifically formulated for an empirical study, and the data collected from these questions are more factual. The pilot-questionnaire used in this thesis, included a limited amount of questions that were made specifically for this pilot-exercise. From the pilot-questionnaire, the benefit of having six answer alternatives became evident in this type of study, as it gave an indication on whether the participants were more positive or negative towards solving the task in terms of the well-being aspect. The pilot-exercise did not include registering the productivity measures with the pilot-questionnaire, of that same participant, which would have been beneficial for conducting a more thorough analysis, and should be included in the larger-scale study. As more participants would be involved in the full-scale experiment, the anonymity would also be intact.

Feedback, after the participants had completed the pilot-exercise, the most common feedback given was that the trigram puzzle was an entertaining task. This raised some questions about the task itself. Although, the task was supposed to be challenging and at the same time not be too boring, the question is, was it too enjoyable? Would this have a big impact on the results? Would it be better to have a task that was more demanding or boring, and could one of those have been a better way of challenge the participants and bring out intrinsic motivation? Knowing how the participants would feel about the task after working on it for a longer amount of time, which is needed in a larger study, is not something that can be commented at this point. Therefore, considering using another type of task could be wise before conducting a larger experiment.

5.0 Discussion

This thesis is based on a theoretical approach, and supplemented by an empirical pilot-exercise. Having a theoretical thesis opened the possibility of looking further into a subject that demands a full-scale empirical study, and which requires more time. As an alternative, a pilot-exercise was conducted to see how a larger-scale study could have been carried out.

5.1 Theoretical Discussion

The research question in this thesis concerns the physical work environment and the effect it can have on individual productivity. Why was this a topic worth looking at? People use a lot of time in office spaces and organizations have been trying to cut cost in this area, the cost-effective solutions that have been implemented are not always optimal for the employees. Like the open plan office, that reduces cost in construction and equipment and is supposed to increase employee efficiency (Kamarulzaman, 2011), still there are only 15% of Norwegian employees that report that they are more efficient in such an environment (Kaspersen, 2014). For an organization, cutting cost in this area is understandable, as the designing of an office space is one of the greatest expenses an organization has (McCoy, 2005). It is still important to keep in mind that office spaces have an impact on the employees, and having a quality space can have positive health effects. Health issues are one of the problems that has emerged when it comes to the work environment, which can be consequences from bad air-quality, temperature, noise and lighting (Bergs, 2002; Leaman, 1995). An organization's employees are viewed as one of the greatest resources it possesses (Heery & Noon, 2008), making sure that the employees experience at work is positive should be a consideration made when designing the workplace, as this can affect the organization's economy by reducing sick leave.

The psychological aspect of the employee is often overlooked (Bergs, 2002), this is something that should be acknowledged when constructing an office space, considering that the human mind is one of the main conditions why the physical work environment has become a more essential aspect now than before (Ratti & Claudel, 2016). The aspect of the physical work environment is becoming increasingly recognized by organizations, and some have been experimenting with this aspect for some time. Take for instance Google, which uses tools such as color, texture and props to create a physical work environment that triggers employee thought processes (Emerald Insight, 2007). There are several factors that influences

an individual when it comes to the physical work environment, however this thesis included only one factor in the hypothesis, color.

The physical work environment factor, color, is assumed to be connected to an individual's well-being, which again would lead to increase in productivity. An individual that experiences well-being in a work situation might perceive the work more positively and behave accordingly, and color can be used as a subtle stimulation to influence behavior (Jalil et.al, 2012). When an individual perceives the work situation in a more positive manner, the likelihood of them being willing to put in extra effort and work harder is greater, which leads to higher individual productivity. Increased individual productivity would consequently have a positive effect on the organization's economy, as it has been suggested that the employees affect the organization's bottom line (Rath & Harter, 2010).

Saying that color can have such an influence by itself is not the case, on the other hand, it is said that color can affect an individual's mood, satisfaction, motivation and performance (Stone, 2001). Meaning that the color aspect of a physical work environment should be carefully considered when designing an office space, along with several other factors.

5.2 Learning Points from the Pilot-Exercise

The pilot-exercise in this thesis is conducted to gain knowledge on how a larger scale study could have been carried out.

5.2.1 Preparation

Recruiting participants

Considering the short timeframe and no use of any external motivation, the recruitment process for the pilot-exercise was a demanding task. It is not only time consuming to gather enough people to participate in a study that requires them to give up approximately twenty minutes of their day for free, as well as to meet up at a specific time and location. People seemed to be more willing to participate if they could have the possibility of conducting a task over their computer, but in the case of testing how people are affected by the physical work environment, this would not be possible.

Advertising

The advertising of the pilot-exercise occurred over social media, and by word-of-mouth. Advertising over social media was not effective as few people responded, people get bombarded with information on these channels every day, having other types of advertising could have been more efficient. The information about the pilot-exercise could have reached more students, and perhaps brought in more participants, this could have been done by flyers, posters etc. The more effective way of gathering participant was to use word-of-mouth, where the word about the pilot-exercise got spread to students at campus which took it further to people they knew and so on. It was noticed that people tended to be more willing to participate if a friend had told them about the pilot-exercise.

Scheduling

The pilot-exercise required participants to show up at a specific time and location, which made scheduling an important aspect. However, it was observed that people who were positive to participate, were often reluctant to set a time and date within the week of the pilot-exercise, and expressed that they would rather prefer to drop by when they saw fit. Considering the one-week timeframe for the pilot-exercise, not knowing when and how many participants would show up at the same time, was not an option. Seeing as there were two rooms available, only two participants could engage in the pilot-exercise simultaneously, which could result in losing participants if more than two showed up at the same time. Working with a schedule also gave an overview of how many participants were signed up in total, which helped make sure that there would not be less than thirty participants in the pilot-exercise. This learning point demonstrates that scheduling is an important aspect of working with a substantial number of people.

5.2.2 Testing

Downtime

A problem that surfaced early in the process of conducting the pilot-exercise, was the participants were often late to their scheduled times. Which could have caused some negative consequences such as the next participant disturbing an ongoing test, or having someone not participate as they don't have time to wait. When the pilot-exercise was conducted, it had been scheduled that each participant had thirty minutes, although in total it took about twenty minutes to complete the task, this resulted in no delays. This may have been too much

downtime, but when it is crucial that everyone that has said yes to participating goes through with the test, it made more sense that the observers waited rather than having the participants wait.

Reminders

A day prior to their scheduled attendance, a reminder was sent out to each participant. The function of the reminder was not only to make sure that the participant would remember to show up to their scheduled time and date, but also to give them a chance of rescheduling if necessary. The reminders were intentionally never sent out during the morning hours, because it was assumed that the reminder could have been more easily forgotten during the day if this was the case. The reminders worked as an important prevention towards unexpected loss of participants in the pilot-exercise.

Manipulation

The obvious manipulation done in the pilot-exercise was not optimal, this would be something that should be done in a subtler way to get more unaffected data. Having a more natural manipulation was not a possibility, as the sample was familiar with the rooms used, any small change would have been noticed.

Trigram Puzzle

The feedback received from some of the participants on the pilot-exercise, was that the trigram puzzle task was enjoyable. This feedback was a little concerning, as the task may not have been as challenging for the participants as intended, which could also have affected the results. It may have been more beneficial to provide a task that was more challenging or less interesting in the pilot-exercise, considering the short timeframe. However, with regards to a full-scale experiment, the trigram puzzle task may not have been as enjoyable with an extended timeframe.

Observer

Having an observer present in the room was necessary so that the correct measures from the productivity task were registered, and to observe if there was anything that would be useful in a larger-scale study. Although, this was not an optimal solution as some of the participants displayed behavior that could be interpreted as discomfort, they talked a lot during the task

both to the observers and to themselves. It would have been preferable to find a solution where the observation is not so prominent.

5.2.3 After Conducting the Pilot-Exercise

Following the pilot-exercise, some learning points became evident. As previously mentioned, the time aspect regarding the pilot-exercise was limited, which also resulted in a low number of participants. Recruiting enough participants, is a task that requires more than a week. The pilot-exercise also has the defect of not registering and comparing the participant's trigram puzzle results to their pilot-questionnaire. This would have made it possible to conduct a more thorough analysis, where the results from the task could have been connected to the participant's answers from the pilot-questionnaire. It was observed that factors like lighting, noise, and air quality, in the two rooms were slightly different. These factors were not possible to control in the pilot-exercise, but should be considered when conducting a larger-scale study. Lastly, the hypothesis requires several colors to be tested, rather than just two, as there might be other colors that can affect individual productivity.

5.3 Further Research

A larger-scale study can be used to test for the hypothesis and answer the research question in this thesis. Conducting the pilot-exercise gave an opportunity to get some insight into how this could be done. In the pilot-exercise a sample of students were tested in rooms located at campus, this was an appropriate solution as the pilot-exercise looks at cognitive abilities and individual reactions (Liyanarachchi, 2002). It would be interesting to do a study in a more natural setting where the variable manipulated would be less obvious, such as an office environment with actual office employees. This would give results that were more suitable for the study on the physical work environment and individual productivity, and the Hawthorne effect could have been minimized.

Although, if a laboratory study is conducted on students, it would be preferable to add more colors into the study. There were only two colors used in the pilot-exercise, but the hypothesis is that color affects individual productivity, which means that other colors should be included. This study connects individual productivity to individual well-being, which is related to elements such as feeling good and happiness (Steemers, 2015). Using other colors that represent these elements would be appropriate, this could be colors like yellow, green, orange

and blue as these are perceived as "happy" (Cimbalo et al., 1978). Such "happy" colors could evoke good mood in individuals, and motivate them to be more productive (Kamarulzaman, 2011). This means that using two colors is not enough to research the hypothesis, to get a better perspective on how individual productivity gets affected by color, using several different colors would give a more precise indication. The study should also be done over several months, so that the data is representative and if any differences are discovered between the individual productivity, the results would be reliable.

One possible way of conducting a large study, would be to do it in an organization that uses the open plan office design, as the number of Norwegian employees that has reported that they are not efficient in such an environment is high (Kaspersen, 2014). It would be possible to conduct a study over a longer period, were the color could be added to the physical work environment, and the different colors would be distributed to different departments. Adding color to physical objects in a workplace can be covered as renovation, making the manipulation subtle. A possible workplace to conduct such a study in could be telemarketing, as it would make it possible to monitor and measure individual productivity through their sales results. This would make it possible to compare results prior to the study, to the results individuals have after a couple of months. Also, including a control group, would give the opportunity to compare results from the different colors environments to an environment without any manipulation.

Doing the study in a real-life situation would mean that the tasks are relevant, the observation is not as evident, and any results would be relevant factor for organizations. The measuring of the well-being aspect should be done by using a questionnaire that is constructed from surveys, where the validity and reliability has already been tested (Johannessen et al., 2011).

6.0 Conclusion

The purpose of this thesis was to explore how the physical work environment affected individual productivity. Although there are several aspects to this subject, the thesis' hypothesis takes a closer look at color, and whether color affects individual productivity. The hypothesis of this thesis is not supported; therefore, it is not possible to conclude that there is any difference in productivity between the rooms. This was not an unexpected result, as the size of the pilot-exercise was too small. Still, going through the process of designing a pilot-exercise, collecting the data and analyzing it, gave valuable insight into how this would be conducted on a larger scale. The hypothesis requires a sufficiently large sample to be properly tested and give any significant results.

The theoretical chapter in this thesis shows that individual productivity presumably is affected by the physical work environment. Individuals can be affected both physically and psychologically by the physical work environment, for example, a negative physical impact is health issues that employees experience, and a positive psychological impact is experiencing individual well-being. Both of which, from a theoretical standpoint, does affect individual productivity.

6.1 Limitations for Pilot-Exercise

The pilot-exercise posed some limitations with regards to the thesis. It was not possible to conduct a full-scale experiment on the hypothesis, considering that the timeframe was limited. The rooms borrowed to conduct the pilot-exercise were only available for a week, and were University property, which meant that making any permanent changes to the rooms were not permitted. This demanded some creativity when choosing how to proceed with the manipulation, and since the pilot-exercise did not have any financial support, the manipulation was obvious for the participants and the Hawthorne effect was present. The limited timeframe made it difficult to look further into more than one factor of the physical work environment.

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Appendix A

Google Offices

Pictured above: From Google's Düsseldorf Offices

Pictured above: From Google's Kuala Lumpur Offices

Pictured above: From Google's Office in Cambridge

All pictures from Office Snapshots (2017)

Appendix B

Rooms used in Pilot-Exercise

Pictures above show the room with the white colored manipulation.
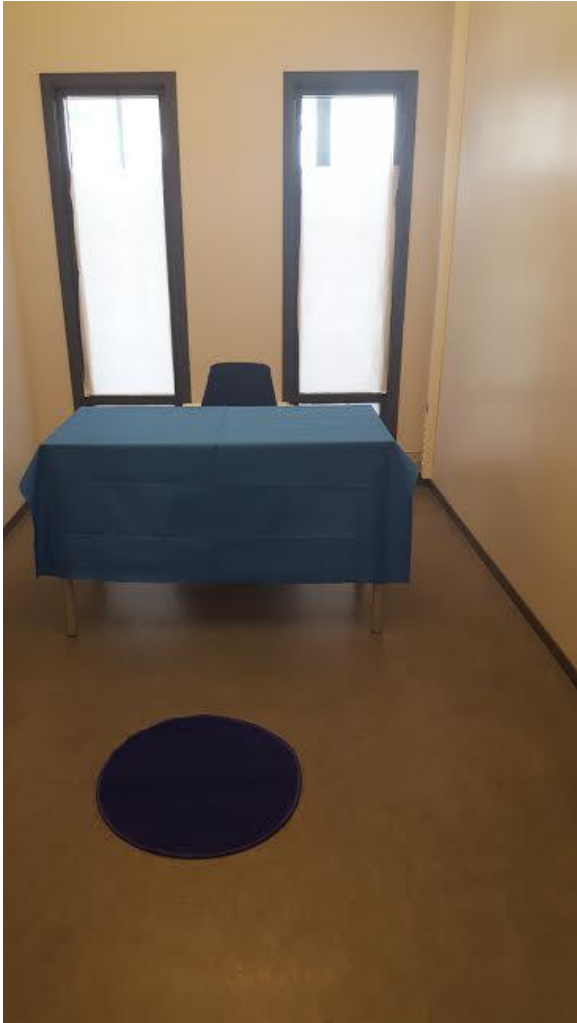
Pictures above show the room with the blue-colored manipulation

Appendix C

Pilot-Questionnaire

1. Under utførelsen av oppgaven, følte du deg:

a)   1   2   3   4   5   6

Svært avslappet   Svært stresset

b)   1   2   3   4   5   6

Komfortabel   Ukomfortabel

c)   1   2   3   4   5   6

  Fornøyd   Frustrert

2. Hvordan opplevde du vanskelighetsgraden på oppgaven?

- o Veldig lett
- o Lett
- o Litt lett
- o Litt vanskelig
- o Vanskelig
- o Veldig vanskelig

3. Hva synes du om resultatet ditt? (Antall figurer laget)

- o Veldig tilfredsstillende
- o Tilfredsstillende
- o Litt tilfredsstillende
- o Litt misfornøyd
- o Misfornøyd
- o Veldig misfornøyd

4. Hvor motivert var du til å utføre oppgaven?

- o Veldig motivert

- o Motivert
- o Litt motivert
- o Litt umotivert
- o Umotivert
- o Veldig umotivert

5. Hvordan vil du vurdere egen innsats?

- o Veldig tilfredsstillende
- o Tilfredsstillende
- o Litt tilfredsstillende
- o Litt utilfredsstillende
- o Utilfredsstillende
- o Veldig utilfredsstillende

6. Hvordan opplevde du å jobbe i dette rommet?

- o Veldig behagelig
- o Behagelig
- o Litt behagelig
- o Litt ubehagelig
- o Ubehagelig
- o Veldig ubehagelig

7. Er du student ved Universitetet i Stavanger?

- o Ja
- o Nei

8. Kjønn:

- o Mann
- o Kvinne

Appendix D

Cronbach's Alpha

```
. alpha spm1a spm1b spm1c spm2 spm3 spm4 spm5 spm6

Test scale = mean(unstandardized items)

Average interitem covariance:      .5840722
Number of items in the scale:             8
Scale reliability coefficient:       0.8470

.


. alpha spm1a spm1b spm1c spm2 spm4 spm5 spm6, std item

Test scale = mean(standardized items)
```

Item	Obs	Sign	item-test correlation	item-rest correlation	average interitem correlation	alpha
spm1a	30	+	0.7727	0.6603	0.3168	0.7356
spm1b	30	+	0.8969	0.8391	0.2782	0.6982
spm1c	30	+	0.6936	0.5536	0.3414	0.7567
spm2	30	+	0.6033	0.4381	0.3694	0.7785
spm4	30	+	0.5062	0.3202	0.3996	0.7997
spm5	30	+	0.6479	0.4943	0.3556	0.7680
spm6	30	+	0.5383	0.3585	0.3896	0.7930
Test scale					0.3501	0.7904

Appendix E

Independent Samples T-tests for Pilot-Questionnaire

Questions used to test individual well-being

Question 1 a

```
Two-sample t test with equal variances

Variable |    Obs       Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+------------------------------------------------------------------
     awr |     15   3.133333   .3762809    1.45733     2.326291    3.940376
     abr |     15        3.2   .3408672    1.320173    2.468912    3.931088
---------+------------------------------------------------------------------
combined |     30   3.166667   .2495206    1.366681    2.65634     3.676994
---------+------------------------------------------------------------------
    diff |          -.0666667  .5077182                -1.10668    .9733469
----------------------------------------------------------------------------
    diff = mean(awr) - mean(abr)                              t =  -0.1313
Ho: diff = 0                                  degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                  Ha: diff > 0
Pr(T < t) = 0.4482        Pr(|T| > |t|) = 0.8965        Pr(T > t) = 0.5518
```

Question 1 b

```
Two-sample t test with equal variances

Variable |    Obs       Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+------------------------------------------------------------------
     bwr |     15   2.533333   .4007929    1.552264    1.673718    3.392949
     bbr |     15   2.666667   .3862724    1.496026    1.838195    3.495139
---------+------------------------------------------------------------------
combined |     30        2.6   .2737563    1.499425    2.040105    3.159895
---------+------------------------------------------------------------------
    diff |          -.1333333  .5566339                -1.273546   1.006879
----------------------------------------------------------------------------
    diff = mean(bwr) - mean(bbr)                              t =  -0.2395
Ho: diff = 0                                  degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                  Ha: diff > 0
Pr(T < t) = 0.4062        Pr(|T| > |t|) = 0.8124        Pr(T > t) = 0.5938
```

Question 1 c

```
Two-sample t test with equal variances
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
cwr	15	2.866667	.3361783	1.302013	2.145636	3.587697
cbr	15	3.2	.3677473	1.424279	2.41126	3.98874
combined	30	3.033333	.2467412	1.351457	2.528691	3.537976
diff		-.3333333	.4982509		-1.353954	.6872874

```
    diff = mean(cwr) - mean(cbr)                              t =   -0.6690
Ho: diff = 0                                 degrees of freedom =        28

   Ha: diff < 0                 Ha: diff != 0                   Ha: diff > 0
Pr(T < t) = 0.2545       Pr(|T| > |t|) = 0.5090          Pr(T > t) = 0.7455
```


Question 6

```
Two-sample t test with equal variances
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
wr	15	2.2	.2225395	.8618916	1.7227	2.6773
br	15	2.6	.2725541	1.055597	2.01543	3.18457
combined	30	2.4	.1768173	.9684684	2.038368	2.761632
diff		-.4	.3518658		-1.120764	.3207644

```
    diff = mean(wr) - mean(br)                               t =   -1.1368
Ho: diff = 0                                 degrees of freedom =        28

   Ha: diff < 0                 Ha: diff != 0                   Ha: diff > 0
Pr(T < t) = 0.1326       Pr(|T| > |t|) = 0.2653          Pr(T > t) = 0.8674
```

Questions used to test individual motivation

Question 2

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
twowr	15	3.733333	.2839629	1.099784	3.124294	4.342373
twobr	15	3.933333	.2481679	.9611501	3.401066	4.465601
combined	30	3.833333	.1862104	1.019917	3.45249	4.214176
diff		-.2	.3771236		-.9725027	.5725027

```
    diff = mean(twowr) - mean(twobr)                          t =  -0.5303
Ho: diff = 0                                   degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                  Ha: diff > 0
 Pr(T < t) = 0.3000       Pr(|T| > |t|) = 0.6001          Pr(T > t) = 0.7000
```

Question 3

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
threewr	15	3.4	.2725541	1.055597	2.81543	3.98457
threebr	15	3.533333	.3065424	1.187234	2.875865	4.190801
combined	30	3.466667	.2019066	1.105888	3.053721	3.879612
diff		-.1333333	.4101877		-.9735648	.7068981

```
    diff = mean(threewr) - mean(threebr)                      t =  -0.3251
Ho: diff = 0                                   degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                  Ha: diff > 0
 Pr(T < t) = 0.3738       Pr(|T| > |t|) = 0.7476          Pr(T > t) = 0.6262
```

Question 4

```
Two-sample t test with equal variances
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
fourwr	15	1.8	.2429972	.9411239	1.278823	2.321177
fourbr	15	1.8	.1745743	.6761234	1.425575	2.174425
combined	30	1.8	.1470007	.8051558	1.49935	2.10065
diff		0	.2992053		-.6128943	.6128943

```
    diff = mean(fourwr) - mean(fourbr)                        t =   0.0000
Ho: diff = 0                                 degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                   Ha: diff > 0
 Pr(T < t) = 0.5000       Pr(|T| > |t|) = 1.0000          Pr(T > t) = 0.5000
```

Question 5

```
Two-sample t test with equal variances
```

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
fivewr	15	2.6	.305505	1.183216	1.944757	3.255243
fivebr	15	2.933333	.3581256	1.387015	2.16523	3.701436
combined	30	2.766667	.2333333	1.278019	2.289446	3.243887
diff		-.3333333	.4707306		-1.297581	.6309146

```
    diff = mean(fivewr) - mean(fivebr)                        t =  -0.7081
Ho: diff = 0                                 degrees of freedom =       28

    Ha: diff < 0                 Ha: diff != 0                   Ha: diff > 0
 Pr(T < t) = 0.2424       Pr(|T| > |t|) = 0.4847          Pr(T > t) = 0.7576
```