

REFLECTION

The P5 thesis stage marks the end of both this graduation research as my student period as a whole. In other to reflect on the process and content of this research, this chapter dives into the different aspects of the journey, from topic selection to changing research designs and learning how to program to findings limitations due to privacy. The chapter aims to reflect in two ways, the first being the reflection on the intended research and how this developed over time and the second being the connection of the research to the master track Management in the Built Environment.

TOPIC SELECTION AND INITIAL RESEARCH

From Management in the Built Environment to Stress in the Work Environment

This research is written as a graduation requirement for the master track Management in the Built Environment (MBE) of the master program Architecture, Urbanism and Building Sciences (AUBS) at the Faculty of Architecture and the Built Environment (ABE) from the Delft University of Technology (DUT).

The master track MBE prides itself in being a managerial program, educating future decision-makers, but having a background in design and stimulating design thinking. The faculty ABE in general states that one of their greatest qualities is that not only the immediate problem is taking into account, but the wider context of its environment. With these perspectives and skills in mind, my graduation journey started a little over a year ago during the MBE Graduation Lab introduction days in February of 2018.

Real Estate Management

For me it was fairly quickly decided that my graduation domain was going to be Real Estate Management (REM). Being very user-minded throughout my entire education, the domain of REM offered in my view the best context to study and develop something that could improve the life's of the users of real estate.

The (work)place to be (healthy)

Within the domain of REM of wide range of possible graduation themes were available, but the theme Workplace & Health caught my eye. The statement associated with this theme was that two folded. On the one hand, a lack of knowledge was growing with the impact of new office concepts in the current society that has a growing problem with stress and burn-outs and on the other hand, new technologies were on the rise that were not known and investigated in the context of the work environment. This seemed for me the perfect theme to do research with the aim to improve the life's of the employees in these work environment that were causing these stress and burn-out complaints.

But stress, is that not a psychological phenomenon? How does that relate to the work environment and REM in general? True, stress is a psychological phenomenon, as well as a physiological one. The danger of this research topic was that it would drift too much to the psychological side, by dissecting all the involved factors and variables that cause stress. In order to put this to a halt, I early on made a choice to not look too deep into the causes of stress, because these are very hard to measure as well, but to focus on the manifestation of that stress in the work environment. In other words, it is not about what actually causes that stress, the research is about influence the work environment has on the reception and buffering of that stress. The end goal of this research is not to eliminate stress, but to reduce it in the work environment, by being able to develop workplaces that support users in not

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

generating too much of it throughout the day. For future (larger scale) research, it would be advisable to team up in a cross-disciplinary research team, to incorporate other perspectives as well, making the research even more valuable.

Geeks and Gadgets

But how to investigate this? During a first quick literature scan, a lot of similar research designs were found, mainly based on big occupational surveys, investigating work environment and workplaces on a general level, combining it with self-rated stress scores. The question that rose from this was: 'Stress is not something new and present in the work environment for decades. Why is it still not better, but might even be worse?' I could come up with two hypothesis based on my own assumptions for this. The first is that employers and decision-makers simply do not want to pay too much attention and money to this, due to a feeling that it will not be solved anyways and is a part of the work life. The second one is linked to the first, being that no actual knowledge exists that tries to quantify stress knowledge about the work environment and thus interventions and programs cannot be properly tested and evaluated.

How to solve this? Besides being a hardworking MBE student, I also have a passion for nerdy stuff and gadgets. With the quick rise of fitness trackers and such over the last few years, the ability to measure oneself on a variety of bio-metrics has become more and more easily available. Most people already use a fitness app for running or cycling, track their step count and some even monitor their heartrate 24/7. So why not do this for stress? And use this information to identify stressful moments in the work environment and perform interventions. Sounds like a plan.

Motivation versus reality

This motivation and ambition to improve the life's of the users of the workplace, the employees, could be done in two ways, a real-time intervention or a long term structural change. In the context of the work environment, the responsibility of execution the real-time intervention would be that of the employee, while the long term structural change responsibility lays with the real estate manager.

The initial plan was to provide a solution for both, however this appeared to be a bit too ambitious. This will be further explained in section 1.2.2.

Ethics of quantified metrics

How does one measure stress in a person? The answer to this was determined to be the use of a smart ring that collects Electrodermal Activity (EDA). This information is a bio-metric and falls under the category of personal health information. This means that it is very privacy sensitive information. In order to be able to collect this, a well documented plan needed to be drafted, considering a multitude of aspects.

One of the first limitations when it comes to privacy that was identified, was the role of employer and employee. Because I performed my thesis research at an internship company, agreements needed to be made about who owns what data and who is responsible for what. The GDPR states that an employer may not monitor personal health information, even with consent from the employee, because of an uneven power situation. So even if the employees were willing to share their data with the company, this wasn't allowed. This resulted into strict privacy management throughout the entire process.

To comply with regulation and legislation, also an application needed to be done to the Human Research Ethics Committee of the DUT. Preparing for this application was an educational experience

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

that helped the process to become more developed. No privacy complaints have been noted throughout the entire process of the research.

A second question about privacy and ethics in terms of quantified metrics that arises, is we even should want to perform quantified metrics in a large scale. Things as stress are natural processes and one could argue that we should leave them be, since they have a purpose in live, to protect your body. Reducing or even eliminating stress in once life could lead to unforeseen problems we are not yet aware of. However, in my opinion stress is a problem in this society caused by society, not by our natural processes. It would therefore be, in my opinion, unethical to not investigate this phenomenal with the tools available. A part of scientific research has always been based on investigating personal information and quantified metrics are in my opinion just the next step in this process.

RESEARCH DESIGN AND METHODS

The research design is based on a operational-empirical research, which is a mixed method approach, combining quantified research with operations research. This research design has remained the same throughout the entire research process. However, some rather large changes have been made after the P2 moment, because it became evident that the focus point of the research plan was off. This will be discussed below.

Before P2

The research aim was two-folded, by creating a smart tool that could support the employee to reduce their stress real-time and help real estate managers reduce stress in the work environment long term. Empirical research before the P2 was conducted by means of a literature study and resulted into a list of variables that were indicated to be of influence on stress. At the same time, the first conceptual designs of the smart tool were created, defining the problems that is needed to solve. The focus of the smart tool for the employee was on supporting the choice for a suitable workplace when his or her stress would become too high. The focus for the real estate manager was to create a new improved version of the work environment, based on the data generated from smart tool.

P2 much on my plate

Just after the P2, it became evident that a large piece of information was missing. Since the aim of the smart tool was to support choosing suitable workplaces, knowledge was needed what workplace *are* suitable for which situation. And this knowledge was not available. Obtaining this knowledge needed a study on its own, leaving no more room to translate this knowledge into a tool that would work for an employee. It became time to kill my darlings.

After P2

The choice was made to change the purpose of the study from creating a smart tool that would support workplace choices for employees, to the quantified knowledge creation of stress in the work environment. This knowledge base could then, in time, serve as a starting point for future research. Thus, the focus became on the empirical creation of knowledge and as method structured observations were chosen. The results from these structured observations would serve as the input for the operational model.

Watch and learn

Drawing from the research that had been performed already, it was still chosen to use the smart ring to perform the stress measurements. Creating objective and quantifiable information was still very important, in order to create a new method in doing stress research in the built environment, thus

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

having sensor data promised a solid new method. There was literature on this measure method, validating its use, however, it still needed to be introduced and prove its use in the context of the built environment. In hindsight, the method delivers on its promises, creating new insights. From now on, this methods can be used to do further research, for instance by testing interventions or doing more specific research to fill in gaps in existing knowledge.

STRUCTURED OBSERVATIONS

The structured observations needs four elements to perform: a location, participants, observers and a observation protocol. This process is designed before the observations start and are limited to the scope of the research, technological limitations, privacy limitations and practical limitations.

Company and location

As mentioned earlier, the observations (or the experiment as it was called towards the participants) was performed at the internship company, Colliers International. This is a company that employs almost exclusively knowledge workers, which are the target population of this research.

The research also focusses on Activity Based Working environments, since these are work environments that stimulate mobility among different workplaces. For the observations, two of the offices of the internship company were used, one in Rotterdam and one in Amsterdam. The Rotterdam office is a fully ABW environment, however the Amsterdam office was more of a hybrid between a traditional and a ABW office. It contained a large part that was dedicated to a single department and other department huddled up together as well, but this is common in ABW as well. While this might not be perfect for the observations in terms of diversification of the workplace use, it also does not harm the observations.

Sample selection procedure

With sample selection, the risk of sample bias is always present. In this research, participants were recruited by recruitment messages. One can always wonder that, in the context of stress, more stressful people are inclined to answer the recruitment call, thus distorting the observations. One limitation that was foreseen, but could not be steered or adjusted, is that people who perceive themselves as very busy, are less inclined to participate, since they have the feeling that it would take up even more of their time.

Initially, there seemed to be a relatively low response rate to the email and the intranet message, but after some time, the mouth to mouth marketing gave an uptake in registrations, resulting in a satisfactory response rate. From these responses, the participants were chosen. The limiting factor in the participant selection, were the available ring sizes. This resulted into a natural division of male and female. In companies with an uneven gender division, this could result in distorted measurements, but this could be adjusted through analysis.

Privacy and ethics

During the selection procedure, privacy was an important aspect. As mentioned earlier, the company was not allowed to know who would participate, but also not who refused to participate, to avoid pressure on employees. Due to this fact, no extra help from the organisation could be given in the recruitment of the participants, outside of the dispersion of the recruitment messages on the intranet. This in hindsight probable did decrease sample bias, since no specific departments or groups were targeted in the selection procedure.

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

In order to have well informed participants, all of the participants that started the observations were obligated to sign a Informed Consent Form, that contained information about the research procedures and future use of the acquired data. No (potential) participants refused to fill in the Informed Consent Form.

Observations

The actual data collection was done in two stages, a pre-observation survey and the observation period. The combination of these data formed the basis for the analysis.

Initial surveying

Alongside and partially after the selecting procedure, through survey inquiry some personal information was gathered about the potential participants. Only participants were allowed who filled in all the informed were eligible to participate in the actual observations.

Smart ring

Using the smart ring during the observations was experimental. While the ring is validated as a research instrument in literature, it was not exactly known what type of dataset would result from it. After having performed the observations, it was realized that the data from it, the stress score, could not be interpret as a representation of someone's absolute stress level. This was no problem for the important analysis, but did remove the possibility to compare groups of people with each other, eliminating the chance to investigate the correlation between age and stress. Since this is not the core question of this research, this was no problem. However, due to the fact that this was not realized beforehand, it could have harmed the potential outcome of the research. Absolute stress is not possible to get from this smart ring, but could be investigated by comparing it to the results from a psychological study on the same participant.

The smart ring worked well, but not without any problems. Sometimes the battery of the rings depleted more quickly than expected, resulting in parts of day with no measurements. One participant could not remove the ring anymore due to a swollen finger and had to be removed in the hospital. No lasting injury incurred and the ring could, after receiving a replacement band, be used again. After this incident, extra attention was payed to make sure that participants did not select a ring that was too tight for them.

The smart rings (10 pieces) were bought from a Finnish Company by the internship company and later sold to the DUT. As compensation for buying this rings, an agreement was made that a part of the results of the research are going to be used to write a white-paper on the topic. This will be done by me, in combination with the internship company. No actual data is in ownership of the internship company, nor are they allowed to see any raw un-anonymized data.

Logbook

During the observation period, participants had to log their workplaces and activities on an interval of 15 minutes. They did not have to do this real-time, but were allowed to do this at the end of the day. Observations aim to be as less intrusive in order to capture reality as much as possible, but at the same time, by filling in the logbook at the end of the day, the accuracy of the observations decreases. For workplace this was not such a big problem, because employees do not switch often and when they do, they have a relatively good feeling for when they did. For activity, this is much harder and resulted in a lower Kappa score.

Before the structured observations started, there was plan to use tracking software to collect and reflect what programs the participants were using at what point in time during the workday. This would

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

be used to map the activities of a person during the day. This method, however, raised two objections. The first being the accuracy and usability of the method. An email program would come up as an email program, but not as the task that was performed in that email program. The same as a webbrowser, or a Word-document, the actual task that someone is doing, is not obvious. The alternative to this, would be to present the findings to the participant at the end of the day, to help them fill in the logbook. The effort-benefit of this structure was deemed infeasible, thus not performed. The second objection, was the willingness of the participants to allow their computer being tracked by a third person. Privacy objections could have been made, and with good reason, to someone looking at their computer use.

Black Box

This raised an interesting disposition to quantified metrics and the concept of 'black box'. With black box is meant that if a system is fully automated, one gives input and receives output, without knowing what happens in the actual system. One can not know if the system sends the input to another system, if it is stored or used for something else then only giving the output. People accept this lack of transparency, because they want the benefit of receiving the output of the black box. While the structured observations were relatively visible in terms of data sharing, if this method is commercialised, probably a black box will be created in which someone's stress information goes. Collecting all of this stress information could be beneficial for future academic research, but could also be sold to insurance companies or even future employers.

Plan for the worse, hope for the best

When it came down to the observations, it was tried to make it as failproof as possible, eliminating complicating concepts, limiting variations of variables and mainly not taking into account the confounding variables. In hindsight, this was a good choice, when looking at the Kappa score, which resulted in *fair*. A more complex observation protocol would have only lowered this.

Two elements were not taken into account, that could have been very interesting in my opinion. These are *sound level* and *occupancy rate*. Both could have a profound effect on stress as suggested by literature. However, due to practical limitations, it was not possible to perform these measurements. I would highly suggest taking these into account when performing future research.

DATA ANALYSIS

One of the objectives for the data analysis, was that it was, for a large part, automated, so that it becomes transferable and allows for easy addition of extra data. This way, the proposed method in this thesis could be strengthened. To automate the analysis process, programming was used.

Python programming

The programming language Python is relatively accessible language, quick to learn, easy to read and easy to interpret, mind it is written in clear code. One of my learning goals for this thesis was to further develop my beginning Python skills and to be able to automate the analysis process. In the end, I succeeded in this objective. However, in hindsight, it costed me more time than I calculated that could have been spend on other things. At the same time, by using a programming perspective, it forced my to dive very deep into my data, getting a good grip and understanding of what data was available and how it could be analysed.

In the end I regard it as a great added value that I used programming, but due to the fact that I had no guidance in my programming process, some parts of it took longer than necessary. Also, programming

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

is an emotional rollercoaster, that really confronts you with your own coping styles. A very relevant insight when doing research into stress.

I would recommend other students to learn how to program and apply it in their research process and analysis. However, I would advise to seek council in an early stage to help design the intended program.

Data limitations

Having collected over 3000 data bites and analysed them, it can be concluded that the introduced method does what it was intended for. However, it does have some limitations, some of which were not foreseen.

The level of detail of the stress score is very high, resulting in a score with multiple numbers behind the comma. This does not represent the same level of detail for the actual stress level of a person, since the precise quantified relation is unknown. Thus, it does not make a whole lot of sense to use two decimals as statistical denotation prescribes. This is related to the fact that no absolute stress levels are known. It is also very hard to create an absolute stress level. This would probably require a saliva sample to determine cortisol levels, psychological assessment and physiological assessment. Way outside of the scope of this research. Therefore, no statements can be made about a person's absolute stress level and only about the differences between situations.

The last big limitation is the large amount of variable combinations of workplace characteristics, activities and activities types that do not result in significant values. While this is not strange, since there are over 1800 combinations and only 3000 data bites, it is still unfortunate, because the knowledge base becomes stronger with more significant values. This problem can be solved by doing more observations. A choice, however, needs to be made if regular observations should be performed in order to represent the actual situation, or interventions and experiments are to be done to fill in the gaps. From my perspective, I would like to see a proposed 'stress less' work environment tested based on the current findings as a next step.

DISSEMINATION

Transferability

The current transferability of the findings is something that needs to be further investigated. Because only one organisation is observed, confounding factors such as organisational culture might have a large impact on the findings, but are not known. As previously discussed, there is still a large gap of variable combination to which no significant values have been found. Further research might display deviation from the findings, or might strengthen current findings.

The method, however, is developed in a way that it is replicable. Since the entire analysis process is programmed, the only need for replicability is to change the input, thus the observation results. In terms of the structured observations, an extensive handout is written for users on how to perform and all related documents such as the logbook are online documents that can be copied and used again.

Validity

The biggest risk of the current research design, comes from the observation protocol. Since the participants are also the observer in this design, personal perspectives could distort the way people perceive certain aspects. In this case that would be the different activities. While the activities have been defined and explained to the participants, their own perception and inaccuracy could lead to

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

different results for each person. Ideally, this would be eliminated by assigning a external consequent observer, or even automate observations, but practical limitations prevent this for this study.

There can still be some debate on the possibility of making the stress score mathematical. No research has been into this phenomenon. The current operational model assumes a linear connection between the stress score and its impact. For now, there is no way of knowing if this is valid. This could be researched by doing an intervention study and seeing what differences result in what stress scores.

Relevance

Societal

The research as it currently is, has less of an social impact than I imagined it to have at the start of the graduation process. In my mind, the new methods that were developed would allow for employees the immediately experience reduction in their stress levels. As discussed before, due to the knowledge gap that was not discovered yet, this turned out to be outside of the scope of the research.

At the same time, were there some expectations that deep and profound new insights in workplace characteristics would have found after the analysis of the results, that could lead to immediate improvements in the work environment. However, due to uncertainty in the cause of correlations, not a lot of hard statements can be made, without testing interventions first.

At the other hand, did this research strengthen some findings and supported some complaints in the work environment, giving those an improved argument to do something about it.

Stress is something that emerges within a person, and this person alone can deal with it. By performing this research, awareness about stress in the people surrounding me and the participants did increase, which could lead to an improved attitude towards stress. The interest in the research from outsiders was astounding, resulting in a lot of knowledge sharing among both professionals and interested persons.

Scientific

While the scientific results are limited in terms of findings on the relation between stress, activity and workplace characteristics, the findings on the developed method are far more important. With this research it is shown that stress research with objective sensor information is possible. This opens up a wide field of new research types that could be performed in the work environment. Not only stress could be researched, other bio-metrics could be used as well, as long as a feasible measurement device is found.

The methods developed in this research is especially useful for the testing of interventions. In contrast to surveys, continuous measurements can be done, with low disruption of daily routine and no questionnaire bias. While there are still limitations and accuracy risks, future research could improve the measurement method and diminish these. Combination of bio-metrics with other sensor data could create an even more profound overview of the workings of the work environment.

Data analysis of these types of studies are, however, more complicated when more data is added. This researched used a very large number of different variables that all can be analysed in combination, but not all findings are evenly relevant. Well defined research designs could positively scope these researches and create manageable studies.

Sectoral

In the real estate management profession some tools for accommodation advises exists, however, they are all completely reliable on the complexity and accuracy of the input. Currently, often due time

REFLECTION ON GRADUATION THESIS: STRESS IN THE WORK ENVIRONMENT

and cost constraints, these inputs are flattened, removing the complexity. This is a shame, especially since the users for which these advises are produced, are diverse in desired and needs. This harms their satisfaction and productivity, which is something that decision-makers should want to avoid.

By adding a tool that gives more quantified and generalised insight into the representation of a diverse and complex problem, more arguments become available to open the dialogue about the added value of real estate, the quality of the work environment and in the end health