Measuring quality of work life through wearable experience sampling

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Useful links:
Project AV Production
Wearable application Github repo
ESM analysis tool Github repo
ID generator Github repo
ID generator webpage
ESM data analysis tool
Digital appendix

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Abstract:
The overall goal of workplace gamification is to introduce more playfulness, motivation and engagement into the daily lives of the employees, and thereby improve their quality of work life(QWL) through play. There have been several attempts to gamify workplaces, or aspects within them. Some more successful than others. There is, however, a lack of research on how to measure the overall QWL of employees in regard to their everyday motivation and flow experiences, whether a gamification effort has been put in place or not. This study aims to suggest a framework for measuring QWL, through the use of a Samsung smart watch, which, through an Experience Sampling Method(ESM) study, measures flow and motivation over a period of time. A prototype of a smart watch application will be developed to this end. The data, which could potentially be submitted through such a device, will be tested during a 2 week ESM test with 4 employees in Nykredit. The results show indications of detected flow experiences in the collected data, however, more testing will be required in potential future iterations. The study is left open-ended, and suggestions for future works will be explored.

Motivation

The topic of this report originally emerged from a previous semester project on Gamification. During the 9th semester internship, in the Medialogy master course, the researcher was working with Onboarding of new employees, through Gamification, in Nykredit, which is a large bank in Denmark. Based on this prior experience with the topic, the researcher joined another Gamification project, which included Novo Nordisk(NN), which is a large medicine production company, also in Denmark, responsible for half of the worlds production of insulin. The involvement in the NN project revolves around measuring the impact of an implemented Gamification system, and how it potentially affects the employees' Quality of Work Life. The NN project ran simultaneously with the present thesis project, and these two projects are very similar in many ways, and they share a lot of common themes. Further details of the NN project can, however, not be disclosed, as a non-disclosure agreement was signed.

Contents

1
Introduction

Almost 40 percent of our waking life is spent on work. Therefore, in order to not waste this amount of time, it is important that we work in places that provide conditions, aligning with our own personal preferences, and thereby feed into our happiness(Csikszentmihalyi, 1997, p. 101). Some organizations regularly measure job satisfaction among their employees, through annual, or possibly more frequent satisfaction surveys, in order to determine, where the organization can improve. However, these measurements tend to be general, and do not focus on employees day-to-day activities. According to Csikszentmihalyi (2008), people are the happiest, when they are able to experience so-called *flow* on a regular basis. By examining employees from moment to moment, it is possible to measure the occurrences of *flow* in, and motivation towards, daily tasks, through the Experience Sampling Method(ESM). This study explores what flow is, and what conditions are required for employees, in any workplace, to experience flow. A two-week ESM study will be conducted on employees in a small digital team in Nykredit, which is one of the larger banks in Denmark. The results from this study shows indications on potential flow experiences by the participants. Furthermore, a Smart Watch application is developed, for conducting ESM studies in workplaces. The aim of this study is to suggest a framework for measuring *flow* states and motivation experienced by employees in any work place in order to determine, if:

- The employee has a job aligning with his/her preferences.
- The workplace has the capacity to provide proper conditions, in which the employees can experience a high quality of work life(QWL).

1.0.1 Initial problem statement

The original aim of this study was to suggest a framework for measuring the effectiveness of applied workplace gamification, in regards to the QWL experienced by the employees. However, throughout the study the focus was changed from gamification to generally measuring the QWL, whether work place gamification exists or not. The following is the initial problem statement, from which the present study originally emerged:

How does gamification impact the quality of work life in a work place?

This study commences by examining and analysing literature on happiness, flow, motivation and QWL. It explores methodologies for measuring QWL with ESM in a workplace, and current state of the art tools for this purpose. Furthermore, it explores how to design and implement a Smart Watch application for a Samsung Galaxy Watch 3, which can potentially be used as an ESM device. The data, which can be obtained through such a wearable device, will also be analysed, and

a conclusion will be reached as to whether Wearable ESM studies can effectively determine QWL experienced by employees at any work place. Finally, the study will provide suggestions for future works within this field.

2
Analysis

Even though all of humanity's, soon to be 8 billion individuals[1], are often in disagreement, whether it be about politics, religion, sports, dinner plans, who gets to play with a certain toy etc, there is at least one thing we all have in common. We all want to be happy in our lives. There might still be differences in what each one of us consider to be a happy life, but regardless; *happiness* is the common denominator. This chapter explores the literature on quality of life, flow theory, motivation, and how they relate to our happiness. Moreover, it explores how gamification has the potential to improve the quality of life within the workplace, or quality of work life(QWL). It also describes how QWL can potentially be measured through the Experience Sampling Method(ESM). The chapter concludes with a set of design requirements for a wearable smart watch application, that can be used in order to measure, whether employees are motivated, how often flow states are reached, and in general, how high the satisfaction with the workplace is.

2.1 Quality of life

According to the Japanese concept of *Ikigai* the secret to a long and happy life is through a mixture of purpose, mission, vocation and profession. It is doing what we love, what we are good at, what the world needs, and what we can get rewarded for(Héctor and Miralles, 2016).

The prototype of positive emotions is happiness, and it is ultimately what all people are chasing, during anything we do, even though we might wish to become wealthy, healthy or famous etc. These are all things we seek as we think they will make us happy. Quality of life, is about developing intentions and goals, that provide us with a meaningful existence. It is about what the person does to be happy. When we set goals for ourselves, the driver behind striving to complete the goals and intentions, is motivation, which helps us focus our attention and creates order within our consciousness(Csikszentmihalyi, 1997, p. 17-23).

2.2 Flow

When we do what we are passionate about, and when we have the skills required to do it, we are more likely to reach optimal experiences, the so-called state of

[1]World population counter: https://population.io/ (visited on: 19-05-2021)

flow(Csikszentmihalyi, 2008, Héctor and Miralles, 2016).
According to Hungarian-American psychologist Mihaly Csikzentmihalyi people are the happiest when in a state of flow. In his book *Flow: The Psychology of Optimal Experience* Csikzentmihalyi states that;

> *"When a person is able to organize his or her consciousness so as to experience **flow** as often as possible, the quality of life is inevitably going to improve,..."*(Csikszentmihalyi, 2008, p. 40)

Flow is the optimal human experience, where people feel enjoyment during activities, in which they are so involved, that nothing else matters, and they do the activity just for the sake of doing it(Csikszentmihalyi, 2008, p. 4). There are 8 major components, which constitute the state of flow. The following is a list of these 8 components, which will be described in more details in the following subsection, based on Csikzentmihalyi's previously mentioned book: *Flow: The Psychology of Optimal Experience*(Csikszentmihalyi, 2008, p. 49-67);

1 A challenging activity that requires skills (C&S)
2 The Merging of Action and Awareness (MoAA)
3 Clear Goals (CG)
4 Immediate feedback (IF)
5 Concentration on the Task at Hand (CoT)
6 The Paradox of Control (PoC)
7 The Loss of Self-Consciousness (LoSC)
8 The Transformation of Time (ToT)

2.2.1 Components of flow

The following subsection describes the 8 components of **flow** presented in the above list.

A challenging activity that requires skills

When a person possesses the necessary skill set to complete challenging activities, whether they are mentally or physically challenging. If an activity undergoes a specific set of rules and provides a goal worth pursuing, one can turn any mundane activity into, what Csikszentmihalyi calls a microflow activity(Csikszentmihalyi, 2008, p. 52). This can be helpful in turning an activity, such as doing the dishes, into a fun and challenging experience worth doing(Héctor and Miralles, 2016). Good games often provide the player with a balanced experience between what the player is capable of and what challenge he/she is presented with. The balance is key as a too high challenge level for a low-skill player might cause a sense of anxiety, whereas a skilled player will be left bored if the challenge level is too low.

> *"A challenge is something that requires stretching one's abilities, trying something new." (Deci and Ryan, 2013, p. 33)*
> *"...for an activity to be interesting, so that positive feedback will increase*

subjects' intrinsic motivation for it, the activity must be optimally challenging." (Deci and Ryan, 2013, p. 59)

In Figure 2.1 below it is shown how a balance between challenge and skill is required, in order to reach the so-called flow channel.

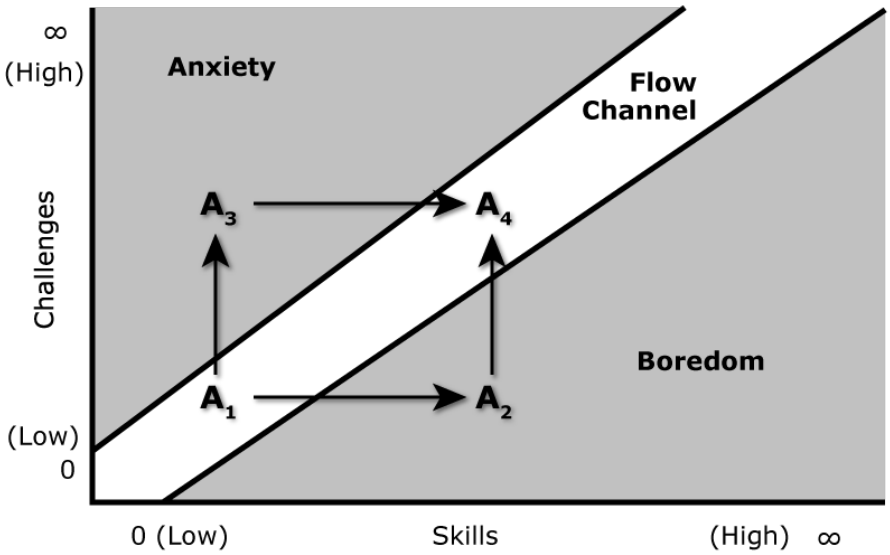

Figure 2.1: The challenge- and skill level balance required in order to reach a state of flow. A1-A4 signify the transitions required in order to stay in the flow channel. E.g. if A1 turns into A3 it means, that the skills need to improve to handle the difficult challenge, and the flow channel is reentered.
Source: Reconstruction of chart from: (Csikszentmihalyi, 2008, p. 74)

The Merging of Action and Awareness

When someone is in the state of flow, there will be no mental capacity left for this person to process any other information, as the full amount of attention is, at that moment, completely absorbed into the activity. The activity and the person's awareness will merge into one, and the activity will seem to be handled almost automatically and effortlessly.

Clear Goals & Immediate feedback

Item 3 and 4 in the above list are closely related, which is why they both are described here in the same paragraph. An optimal flow experience requires the activity to have very clear and explicit goals. It also need to provide immediate feedback in order to indicate how close/far a person is in the process of reaching the goal of the activity. However, creative activities are often an exception as an artist or a music composer might not have a particularly clear goal to strive for, when beginning to create a work of art. Creative people need to have internal and personal guidelines, from which an end goal can eventually emerge during the course of the activity, otherwise a state of flow is not possible.

Concentration on the Task at Hand

Everyday experiences can affect our mental states in pleasant or unpleasant ways. This is why a deep concentration on the activity is necessary in order for the flow experience to be present. As previously seen in item 2 there is a finite capacity of psychic energy and therefore, during flow, there is no mental space left for outside worries to interfere with the task at hand.

The Paradox of Control

There is a clear distinction when it comes to consequences during a person's ordinary life and consequences during games or hobbies. Failure in one's job might result in getting fired or losing the company money, whereas failure in games have no real impact in one's life. In the state of flow the person feels a sense of control of uncertainties, and has no fear of failure, even though the situation is still likely to fail due to exterior influence. An example of this is gambling, as a person addicted to gambling might have a sense of control over the outcome, but the objective reality is very uncertain.

The Loss of Self-Consciousness

People often spend a lot of energy worrying about, how they are perceived by the world around them. If a person walks down the street, and notices other people gazing in his/her direction, it is easy to become self-conscious. People also tend to become aware of physical needs when they, for instance, become hungry or thirsty. However, in a flow state, they become one with the activity, and their self-consciousness disappears, to a degree, that they do not even acknowledge a feeling of hunger, and they are not preoccupied with themselves.

The Transformation of Time

One of the most common elements of flow, according to Csikzentmihalyi, is the feeling of time being distorted. When in flow, it can often feel as if hours pass by in minutes, and the person might not even realize, that it has suddenly become dark outside the window, when they exit the flow experience. The opposite can also occur, where, for instance, dancers in flow, can perform an action, which takes seconds to do, but it can feel like time slows down in that particular moment.

2.2.2 Summary

It is not a requirement for all of the components to be present at the same time in order to enjoy an activity. However, when they are all present, a sense of deep enjoyment can be experienced, as the conditions of flow have been met(Csikszentmihalyi, 2008, p. 49). Therefore, one should strive towards introducing these components into one's daily life on a regular basis, through activities, that bring enjoyment. In general *flow* often makes an appearance in the literature of gamification(Burke, 2016, Chou, 2019, McGonigal, 2011, 2015, Ichizli-Bartels, 2019). One example of this is in the book *SuperBetter: A revolutionary approach to getting stronger, happier, braver*

and more resilient by McGonigal (2015), which is about how she overcame a severe concussion through gamification. Another example is in the book *Self-Gamification Happiness Formula: How to Turn Your Life Into Fun Games* by Ichizli-Bartels (2019). Here she describes how one can improve one's enjoyment of otherwise mundane activities, through self-gamification. This applies to one's personal life, as well as during the work life. If the type of enjoyment, that flow brings, is never experienced at the job, it might be time to look for something else to do.

2.3 Quality of work life

It is difficult to generalize what constitutes quality of work life(QWL), as the subjective experience tends to be individual. Not all jobs are the same and not all tasks in one's job have the same characteristics. Does the job consist of managing others, or is the individual worker a part of the subordinate group? Adults have reported less happiness during work compared to free time(Csikszentmihalyi, 1997, p. 36). This is ironic as Csikszentmihalyi (2008) has previously stated;

> *"Ironically, jobs are actually easier to enjoy than free time, because like flow activities they have built-in goals, feedback, rules, and challenges, all of which encourage one to become involved in one's work, to concentrate and lose oneself in it."*(Csikszentmihalyi, 2008, p. 162)

In contrary to free time, more flow experiences are reported at work(Csikszentmihalyi, 1997, p. 59). The positive feeling of flow is often produced, during work, as the conditions for regular flow activities might exist at the work place. The work environment is much like a game environment. Some work related tasks might have high challenge and skill levels(See item 1). The goals are often clear and the feedback is immediate(See items 3 and 4). There is often a high level of concentration involved handling various tasks(See item 5). There might be a sense of control and ideally very few distractions(See items 6 and 2)(Csikszentmihalyi, 1997, p. 35-38, p. 59)(Pink, 2011, p. 127).

QWL can not be seen as separate to general life outside of work, as general life tends to affect our mental state, which might cause distractions during everyday work life. If a person is preoccupied with something that occurred at home, it might be hard to reach a level of focused attention and concentrate on the work related task(Csikszentmihalyi, 1997, p. 28).

Therefore, when exploring QWL, one should not ignore the significance of, how the life outside of work can play a large role in how a person is feeling on the job(Csikszentmihalyi, 1997, p. 62). Afroz (2018) conducted a systematic literature review of articles published between 2001-2017, to identify the most vital factors of QWL. Ranking at number 5 of the 13 factors, ordered through Pareto analysis, according to occurrences in the literature, is Work and Total life space, where a balance between work- and general life is important for QWL. Below is the ranked list of factors from the study(Afroz, 2018):

1 Adequate and fair Compensation (A&FC)
2 Opportunities for Growth (OG)
3 Safe & Healthy Working Condition (S&HW)
4 Social integration & Cohesiveness (SI&C)
5 Work & Total Life space (W&TL)
6 Supervisor (Su)
7 Human Progress Capacities (HPC)
8 Constitutionalism, Justice and Equity (CJE)
9 Rewards and Recognition (R&R)
10 Job Security (JSe)
11 Autonomy & control at work (A&C)
12 Participation in decision-making (PDM)
13 Communication (Co)

According to Csikszentmihalyi, there are generally 3 reasons for a lack of enjoyment towards the job. Firstly, one can feel as if the job is pointless, and might even cause harm to society, which the worker has to tolerate on a daily basis. Secondly, the work becomes boring and routine, and there is no progress or variety in challenge(Item 2 and 7). Thirdly, the job can be stressful, if supervisors(Item 6) or colleagues expect too much from the worker, and provide no recognition(Item 9) for the work being done. Stress is destructive for the flow experience(Csikszentmihalyi, 1997, p. 106). Csikszentmihalyi's states that more money(Item 1) and security(Item 10) is, contrary to popular opinion, not as important as the 3 above mentioned reasons for disliking one's job(Csikszentmihalyi, 1997, p. 101-102). In his book *Drive: The Surprising Truth About What Motivates Us*, Daniel Pink also states that:

> "It is not how much money we make that ultimately makes us happy between nine-to-five. It's whether our work fulfills us."(Pink, 2011, p. 202)

It is, however, the case that some people, are seemingly satisfied with a decent salary and some job security(See items 1 and 10), however, since work constitutes such a large portion of the waking life, this attitude is only going to be a waste of time. It is largely the worker's own personal responsibility to induce a more enjoyable work experience, if no one else is providing it(Csikszentmihalyi, 1997, p. 101).

2.3.1 Summary

Even if no flow experience is achieved, activities that are in line with our own goals and preferences, can improve our state of mind. Therefore, one should take ownership over one's actions, rather than living like puppets, who perform actions out of a sense of obligations, as the strings our being pulled from the outside(Csikszentmihalyi, 1997, p. 137).

2.4 Self-determination theory

Self-determination theory(SDT) revolves around human motivation, and is developed by psychologists Edward Deci and Richard Ryan. Deci and Ryan (2013)[2] have identified that motivation can either be extrinsic, where people are motivated by external factors, or intrinsic, where the motivation comes from within the individual. Intrinsic motivation and self-determination comes from 3 intrinsic psychological human needs, which are applicable throughout different cultures; *Autonomy*, *Competence* and *Relatedness*(Deci and Ryan, 2008a, Sailer et al., 2017). The need for competence makes people seek out challenging activities, which are optimal for their own abilities(See item 1 in section 2.2)(Deci and Ryan, 2013, p. 28). When people are intrinsically motivated they experience their actions as self-determined/autonomous(See item 11 in section 2.3), and they will be more invested in the activity and have more positive experiences(Nix et al., 1999). Factors that undermine a perceived autonomy and competence, undermine intrinsic motivation(Kapp, 2012, p. 63-64)

Nix et al. (1999) and Deci and Ryan (2008b) make distinctions between autonomous motivations and controlled motivation. They state that intrinsic motivation is by definition autonomous, but extrinsic motivation can, however, also contribute to the self-determined mindset depending on the degree to which it is autonomous or controlled. The reason being, that extrinsic motivation can be internalized if a person identifies with the value of the activity(Deci and Ryan, 2008a). Autonomous motivation has shown to promote various positive outcomes, such as better productivity, enhanced creativity, better grades, less burnout at work(Deci and Ryan, 2008b). It promotes a sense of agency, whereas controlled motivation promotes a feeling of pressure and tension into doing an activity(Nix et al., 1999).

2.4.1 Self-determination at work

Throughout his book Pink (2011) describes how human motivation has evolved alongside the jobs of the human race. He uses a software version metaphor to describe, how the motivation has evolved. According to Pink (2011) *Motivation 1.0* was about how humans were motivated to work towards satisfying hunger and carnal needs. At this point in time humans were working on finding/gathering food and also to procreate. General survival was the primary motivation. The software update, *Motivation 2.0*, came on a later stage of human evolution, where jobs, at this time, were based on being rewarded or punished for doing a good or bad job respectively. It was extrinsically based. Finally, *Motivation 3.0* is more in line with how many job types can be characterized in today's modern world. An increasing number of job tasks, that are handled by the modern day work force, require creative problem solving and thinking. Where *Motivation 2.0* was mostly about compliance,

[2] *Intrinsic motivation and self-determination in human behavior*: Originally published in 1985 (https://openlibrary.org/books/OL2531771M/Intrinsic_motivation_and_self-determination_in_human_behavior)

Motivation 3.0 is more engagement oriented(Pink, 2011, p. 111).

Deci and Ryan (2013) touch upon a few of the factors in the above QWL list presented in section 2.3, such as *Autonomy & control at work*, *Opportunity for Growth/Human Progress Capacities* and *Safe and Healthy Working conditions*(See items 11, 2/7 and 3) as they state that:

> *"one can conclude that a higher quality of work life is associated with the opportunities to be autonomous and to develop competencies in a safe environment"*(Deci and Ryan, 2013, p. 298)

Reward structures(See item 9), need to be carefully considered as, they can be perceived as being controlling and thereby undermine intrinsic motivation(Deci and Ryan, 2013, p. 298-299). Goals can also be distracting if they targeted towards obtaining an extrinsic reward, as parts of the individual's attention will be allocated towards the reward and thereby prevent optimal performance(See items 3 and 2)(Deci and Ryan, 2013, p. 237). Rewards and feedback(See items 4) structures should be applied in ways, in which they are perceived as informational, which will give a sense of the work being appreciated, which will in turn help in preserving intrinsic motivation(Deci and Ryan, 2013, p. 300).

Much research has shown that organizations that provide workers with conditions for operating in an self-determining way, such as providing opportunity for creativity, flexibility, and self-regulation, works positively towards both an organizational goal of profit and a higher QWL for the workers(Deci and Ryan, 2013, p. 294). Moreover, depending on supervisor's(See item6) orientation, towards either a controlled or autonomous in regards to their management of the subordinates, the subordinates' QWL can also be impacted. If supervisors provide the conditions for the workers to be autonomous, it has shown increases in their satisfaction with their pay(See item1), more secure in their jobs(See item10) and more trust in the organization(Deci and Ryan, 2013, p. 302-303). Furthermore, (Deci and Ryan, 2013, p. 295-298) also describe the positive effect of employee participation in regards to decision-making and management(See item 12).

2.4.2 Summary

When the basic psychological needs, *Autonomy*, *Competence*, and *Relatedness* are being fulfilled, our experience of an activity can be one of enjoyment, as we are more likely to become intrinsically motivated and self-determined towards the activity. In recent decades there has been an increased focus on facilitating intrinsic motivation and self-determination as it seems to be profitable for organizations, and it has also had the positive consequence of increasing QWL for the employees(Deci and Ryan, 2013, p. 298). With the advent of technology there has also been more attention on motivating workers at their jobs using workplace *Gamification*.

2.5 Gamification

McGonigal (2011), a game designer and Director of Games Research & Development at the Institute for the Future[3], describes in her book *Reality Is Broken: Why Games Make Us Better and How They Can Change the World*, how society generally wrongly makes distinctions between work and play. She advocates for the potential of games, and how they can be used to increase happiness. She has defined 4 components, which are according to her, common to all games. Rules, goals, feedback(See items 1,3 and 4 in section 2.2) and voluntary participation.

> *"The more a job inherently resembles a game—with variety, appropriate and flexible challenges, clear goals, and immediate feedback—the more enjoyable it will be regardless of the worker's level of development(Csikszentmihalyi, 2008, p. 152)"*

Gamification has previously often been defined as a variation of the following statement; *Gamification is the application of game-design elements and game principles in non-game contexts*(Chou, 2019, Sailer et al., 2017, Werbach and Hunter, 2012). More recently, however, another definition of gamification has emerged from the litterature:

> *"...intentional process of transforming any activity, system, service, product, or organizational structure into one which affords positive experiences, skills, and practices similar to those afforded by games..."(Gerdenitsch et al., 2020)*

Gamification aims to apply play-full experiences onto experiences in order to make these activities more motivating and engaging. It is not the same as serious games or simulations, where players are taken out of the regular contexts. Gamification embeds various game elements into the activity itself, in order to motivate the user towards some intended behaviour, within the regular context of the activity, in an attempt to make the experience enjoyable and entertaining(Warmelink et al., 2020).

The most commonly used approach to applying gamification is through the use of points, badges and leaderboards(PBL), which is why gamification is often associated with these 3 game design elements. This is, however, an oversimplification of what constitutes gamification. According to (Kapp, 2012, p. 12-13), it is unfortunate that these elements are so commonly associated with the term *Gamification*, as they are the least exiting and useful elements of game-thinking. Even though they have a place in gamification they are not the only elements to consider for a designer(Chou, 2019, p. 17-18). Sailer et al. (2017) ran a study, where some of the most common game design elements were evaluated against, how they satisfied the 3 psychological needs(See section 2.4). It was found that badges, leader-boards and performance graphs satisfied the need of *Competence* and partly satisfied *Autonomy*. It was also found that avatars, meaningful stories and team mates had an impact on *Social Relatedness*. In his book, *Actionable Gamification: Beyond points, badges, and leaderboards*, Chou (2019) presents a framework, called Octalysis, for designing and

[3]Jane McGonigal website: https://janemcgonigal.com/meet-me/ (Visited on 04-04-2021)

analysing gamification. His framework is built upon an octagon shape, where 8 motivational core drives are placed(See Figure 2.2).

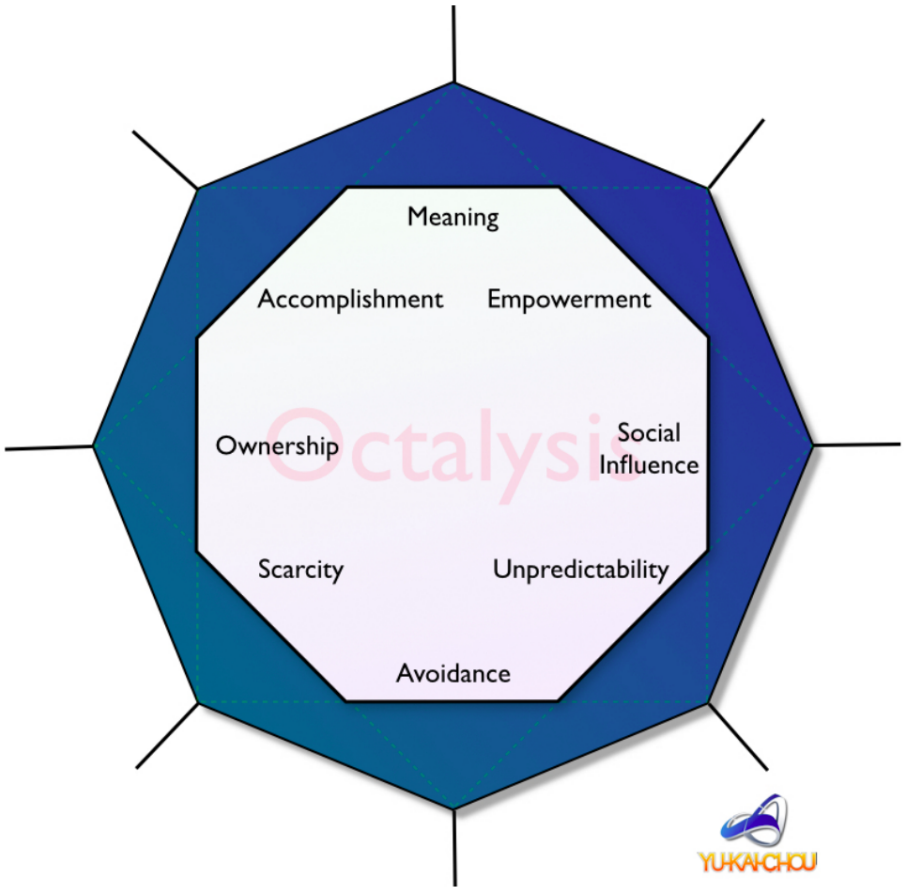

Figure 2.2: Figure showing how the 8 motivational core drives, of the Octalysis framework, are placed in an octagon shape. Placed on the left hand side are the extrinsic core drives, and on the right side are the intrinsic. The topmost core drives are positive and empowering, whereas the core drives placed in the bottom are mostly negative and controlling.
Source: (Chou, 2019, p. 24)

2.5.1 Octalysis core drives

This subsection briefly describes the 8 core drives of Octalysis according to Chou (2019).

1 Epic Meaning & Calling (EM&C)
2 Development & Accomplishment (D&A)
3 Empowerment of Creativity & Feedback (EC&F)
4 Ownership & Possession (O&P)
5 Social Influence & Relatedness (SI&R)
6 Scarcity & Impatience (S&I)
7 Unpredictability & Curiosity (U&C)
8 Loss & Avoidance (L&A)

Epic Meaning & Calling

This drive is about a people feeling like they are contributing to something that is greater than themselves. In games this is often supported by a strong narrative such as a hero saving the world(Chou, 2019, p. 25,65-88). Finding a higher purpose in life is also one of the cornerstones of *Ikigai*(Héctor and Miralles, 2016).

Development & Accomplishment

The traditional PBL approaches of gamification reside within this drive. It is about progress, mastery, competence, developing skills and overcoming challenges(See item 1 in section 2.2). Besides the PBLs, one of the common game techniques, providing an indication of a players progress, is the progress bar, where players can follow along with their progress, and future milestones are indicated. When introducing the progress bar, LinkedIn saw a 20% increase in users completing their profile, as an unfinished progress bar can seem taunting(Chou, 2019, p. 25-26,89-122).

Empowerment of Creativity & Feedback

This core drive ties into the psychological need of autonomy, as it relates to the satisfaction of being creative and receiving immediate feedback(See item 4 in section 2.2)(Chou, 2019, p. 26,123-159)

Ownership & Possession

This is an extrinsic motivational core drive which relates to accumulating wealth in the form of virtual goods or currency. It can be tied to the QWL item of compensation(See item 1 in section 2.3)(Chou, 2019, p. 26,160-194).

Social Influence & Relatedness

The psychological need of *relatedness* plays a direct part here and is therefore also located on the intrinsic side of Octalysis. It contains elements of mentorship, social acceptance, collaboration and competition, which can be present in games(Chou, 2019, p. 27,195-229).

Scarcity & Impatience

This drive is about people's urge to obtain something simply because it is unobtainable or hard to get(Chou, 2019, p. 27,230-268).

Unpredictability & Curiosity

This is a primary driver in gambling addiction, which is why it is placed in the negative lower part of Octalysis. It makes players curious to see what happens next even though they are not in control of the outcome. It can, however, also be implemented in games in positive and fun ways through elements, such as easter eggs and mystery boxes(Chou, 2019, p. 27-28,269-306).

Loss & Avoidance

Loss & Avoidance is when players do anything to avoid something negative from happening. If a player has spent years in a virtual game world exploring, collecting, evolving etc. the player will have a hard time suddenly quitting the game as all the time spent will become wasted. In the real world this core drive can also be related to the fear of losing ones job(See item 10)(Chou, 2019, p. 28,58,307-338).

2.5.2 Summary

In the above section it has been described how gamification can potentially be useful in providing motivating conditions in the workplace environment. It can be toxic for an organization if employees are not motivated and engaged in their work. Gamification has a place in today's modern economy as the generations, currently entering the workforce are people, who grew up with modern technology, video games and the internet. This generation is often labelled Generataion Y or *Millennials*. Therefore many of them are used to being motivated through games, and the younger Generation Z will soon follow(Chou, 2019, p. 58-59).

2.6 Measuring QWL

In the 70s Csikszentmihalyi developed a method for measuring the quality of daily life of the test subjects participating. The method is called Experience Sampling Method(ESM), and it allowed researchers to get a detailed view into peoples daily life. Every day, during the test period, participants would randomly be signalled about 8 times throughout a day, and were asked to write down how they felt, what they were doing, who they were with. Furthermore, they were asked to fill out scales indicating their state of mind at the particular point in time, when they were signaled. Originally, Csikszentmihalyi used electronic pagers or beepers to signal subjects, and when signalled, the subjects wrote down all of the above mentioned on a physical piece of paper. This method reduced recall biases, as it functioned as a moment-to-moment snapshot of subjects' state of mind(Csikszentmihalyi, 1997, p. 15)(Csikszentmihalyi, 2008, p. 99). An alternative method for measuring a state of mind, is the so-called Day Reconstruction Method(DRM). DRM has also shown to provide researchers with meaningful data, and the advantage of this method is, that it decreases the respondent load, compared to ESM. However, the method has also been criticized in regards to recall bias, as it involves participants to reconstruct meaningful events at the end of the day through time diaries(Han et al., 2019).

In the technological climate of modern day, there are several alternative devices, that can potentially be utilized in order to conduct ESM studies. Pagers and beepers have been replaced by smartphones, smart watches and even glasses(Hernandez et al., 2016). Devices such as smartwatches also provide an opportunity to measure psycho physiological responses, such as heart rate, blood oxygen and stress, simultaneously with participant's own self-reporting, which potentially brings a new dimension to ESM studies. Depending on the type of workplace, however, there

might be an issue in using smart watches, as employees are not allowed to wear any type of jewelry. Workplaces, where employees are restricted by hygienic standards and/or are handling sensitive materials, such as medicine production, might not be able to wear watches or have their smartphone nearby during their work.

Hernandez et al. (2016) conducted a study comparing the performance of various devices in a ESM context, where the smart watch received a higher score in regards to Usability, and a slightly higher score, than the smart phone, in terms of device comfort. It was, however, limited by the screen size, which made the design of the different scales more challenging. In another recent study, Francés-Morcillo et al. (2020), tested which design requirements to consider, when designing wearable devices. Aside from the technological aspects of the device, it is also important to consider the human aspects, meaning that these design should ideally involve users throughout several iterations, in order for the user to be satisfied and comfortable with the end product. 7 experts were asked to respond to a survey, in which they were asked to eliminate or add categories, which should be considered when designing wearables. The full list of design requirement categories is listed below along with descriptive keywords:

1. Comfort (Shape, breathability, obtrusiveness, weight, etc.)
2. Safety (Harm, anxiety)
3. Durability (Resistance)
4. Usability (Intrusiveness, simplicity)
5. Reliability (Precision, effectiveness)
6. Aesthetics (Fashion, customization)
7. Engagement (Long-term use)
8. Privacy (Privacy, subtlety)
9. Functionality (Works properly)
10. Satisfaction (User is satisfied with device)

Smart watches are practical ever-present devices, which do not require much from the user to glance at, as it is always conveniently worn on the wrist. A main design concern, when it comes to wearables, is comfort. Therefore, they should not get in the way, and they should be light(Preece et al., 2015, p. 215,354). When using preexisting wearable devices, such as smart watches, one has to assume, that the manufacturer/designer, already has considered the above list to some extent for the device itself, leaving only the added software suitable for undergoing further testing. Therefore, the design requirements presented in the above list, should be considered on an application level, rather than a device level. For example, Usability, should ensure that the application, implemented onto the device, undergoes testing within the criteria for good Usability, such as Efficiency, Effectiveness, Easy to learn, Error tolerance and Engagement(Gregersen and Wisler-Poulsen, 2009, p. 19).

2.7 State of the art

This section will explore various systems, which could potentially be used to conduct ESM studies, in order to measure the test subject's state of mind during their work.

2.7.1 Samsung Smart Watches

Due to the researches access to various types of Samsung Smart Watches, through Aalborg University CPH's SMILE Lab, they will here be included in the State of the Art. It is important to note, that this is not an exhausted list of smart watches, potentially eligible for conducting ESM studies. There are many other prominent smart watches available for this purpose. Samsung has created a few different versions of smart watches over the past couple of years. Figure 2.3 shows 3 of these watches, which are regular consumer watches.

Figure 2.3: Image showing a Samsung Galaxy Watch Active 2(Left), Samsung Galaxy Watch 3(Center), and Samsung Galaxy Watch(Right).
Source: Image downloaded from https://www.techradar.com/news/best-samsung-smartwatch-finding-the-right-tizen-wearable-for-you (visited on: 30-04-2021)

The above Samsung watches run on a Tizen based operating system, and applications for them, can be developed using Tizen Studio[4]. Tizen provides an opportunity to develop Native applications using the C/C++ programming languages, however, simpler applications can be developed using standard web languages(HTML/CSS/JavaScript).
Moreover, through the device's Human Activity Monitor, it is possible to gain access to the integrated sensors, used to measure the health information of wearers of these watches[5] As previously stated in section 2.6, some workplaces, restricted by hygienic or otherwise sensitive standards, will not accept, these types of regular consumer devices to be worn by employees during their work. During this study the researcher was simultaneously involved in another research project, at a large medicine production company. Due to the sensitivity of the handled material and

[4]Downloading site for the Tizen Studio IDE, which is used to develop, compile and test applications, either through an Emulator, or through a physical remote device, which can be connected via a local network: https://developer.tizen.org/development/tizen-studio/download (visited on: 30-04-2021)

[5]Documentation page for the Human Activity Monitor: https://docs.tizen.org/application/web/guides/sensors/ham/

explosion dangers, it is not allowed, for the factory workers to wear smart watches, or use smart phones. However, some of these types of companies, might have a less restrictive production, where it could potentially be possible to use these types of devices, provided that they are ATEX approved. An ATEX approval is required in work places handling explosive materials(ATE). Luckily, ATEX approved alternatives to the above mentioned Samsumg Smart Watches do exist, which are also Tizen based, rendering the applications developed for the Samsung watches easily translatable for these ATEX approved watches as well[6].

2.7.2 Online ESM applications

Several online ESM applications do exists, which provide convenient interfaces for conducting and planning ESM questionnaires, and can be automated to signal participants at random or planned point in time. This subsection will describe a few of these online tools available.

2.7.2.1 MobileQ

MobileQ is a free open source tool, which is developed for conducting Smart Phone-based ESM studies(See Figure 2.4)[7].

Figure 2.4: MobileQ logo.
Source: Image downloaded from https://mobileq.org/ (visited on: 30-04-2021)

Unfortunately, due to the open-source nature of this application, it is only tested properly on a very limited amount of specific phones, and still has issues on other phones. This means that, in order to conduct an ESM study on participant's own private phones, it would require them to own specific phones, which are on the list of tested phones, to avoid these known issues.

2.7.2.2 Team Scope App

Team Scope App is a commercial alternative to the above mentioned open-source application. It requires a subscription in order to access the functionalities, which are required to conduct ESM studies(See Figure 2.5).

[6]URL for ATEX approved smart watches and phones, which could potentially be used for sensitive production companies: https://www.atexshop.com/buy-explosion-proof-smartwatch-the-new-smart-exr-watch-01-online.html (visited on: 30-04-2021)
[7]MobileQ website: https://mobileq.org/ (visited on: 30-04-2021)

Figure 2.5: Team Scope logo.
Source: Image downloaded from https://www.teamscopeapp.com/ (visited on: 30-04-2021)

Team Scope provide a 7 day trial, giving access to a convenient and easy-to-use editor of mobile-based ESM questionnaires, which makes it possible to setup a study, where signals can be controlled and randomized in different time intervals etc. They provide companion applications on iOS and Android phones, which broadens the range of compatible phones, which can be used to respond by participants. However, in order to conduct a proper longitudinal ESM study, one has to pay for the subscription. There are several similar mobile-based alternatives similar to the Team Scope App[8], however, no such system was found for conducting ESM studies on Wearable devices.

2.8 Summary

Throughout this analysis chapter literature on quality of life and positive psychology, has been explored. It was found that quality of life can improve, when a person is able to obtain regular *flow* experiences. The optimal experience of *flow* has been described, followed by an exploration into *QWL*, and it was discovered that *flow* experiences require specific conditions in the workplace in order to become possible. Furthermore, *flow* requires an effort from the individual, which therefore requires the individual employee to be self-determined. *SDT* and *motivation* was described in relation to employee motivation at the workplace. Moreover, the *motivational* aspects of *gamification* was described, as it has become increasingly popular in modern workplaces in order to create an environment, where work and play are merged into one, making it a playful and motivating work place. It was also described, how modern devices, such as Smart Watches can potentially be used to measure employees state of mind and psycho physiological responses, such as heart rate, from moment to moment, and thereby possibly identify, how they are *motivated* and if they achieve regular *flow* states. This measurement can therefore be helpful in determining, if particular workplaces provide the proper conditions for an elevated sense of *motivation*, *flow* and *QWL*.

[8]Teamscope blog of ESM alternatives: https://www.teamscopeapp.com/blog/6-apps-for-experience-sampling-method-complete-guide (visited on: 28-05-2021)

2.8.1 Research question

The analysis and literature review sections above all contribute to the formulation of the following research question;

> "How can a Wearable Experience Sampling Method application be used to measure, the degree, to which workplaces provide proper conditions for motivation and flow, and thereby are eligible for high perceived quality of work life amongst the employees?"

The main reason for choosing ESM rather than alternatives, such as DRM, is to gather data in an efficient and non-intrusive way. Since DRM requires a text based time diary, it would not be ideal for a Smart Watch, as typing on a Smart Watch is neither efficient nor convenient. Samsung Watches do offer a speech-to-text functionality, for a few languages, however, this would not be an ideal interaction form, for example during meetings, if working in an office, or in noisy work environments, if working at a factory or a construction site etc. Some smart watches might have alternative ways of typing, for example by the so-called Swyping, or the like, where users drag their fingers from letter to letter, and the device assists in predicting and auto-completing words(Preece et al., 2015, p. 199). However, since any specific activity is irrelevant for the present study, as the focus is on an overall QWL, text based items, such as; *"What were you doing?"* and *"Who were you with?"*(See section 2.6), can be removed or adjusted. This leaves only general scales for rating different aspects of the state of mind in the moment.

2.8.2 Design requirements

This section describes a list of design requirements for developing a Wearable ESM application for a smart watch, which could potentially be used to measure flow, motivation and thereby overall QWL amongst employees in suitable workplaces.

2.8.2.1 Functional requirements

- Efficient and unobtrusive
- The users should see their progress
- Ability to measure flow and motivation on a moment-to-moment basis
- Ability to gather self-reported and psycho physiological data
- The survey items used should be as fulfilling as possible in recording flow states, motivation, and QWL despite the limitations of the device used

2.8.2.2 Non-functional requirements

Efficient and unobtrusive
A high level of Usability will ensure the applications efficiency and thereby also decrease it's obtrusiveness. In order to ensure a minimal amount of disturbance during a workday, this is a crucial requirement. A participant should be able to respond to an ESM signal in the shortest amount of time possible and return to his/her work. Therefore the time spent in the application will be measured.

The users should see their progress
In order to ensure a high completion rate amongst the users of the application, a progress indicator will be implemented, for the user to be able to track their progress and see how far they are from the goal of a complete response.

Ability to measure flow and motivation
The items implemented into the application, should revolve around the elements of flow(See the list presented in section 2.2). Furthermore, it should also include items related to the element of motivation(Autonomy, Competence and Relatedness).

Ability to gather self-reported and psycho physiological data
Aside from Likert type items, used for self-reporting the user's state of mind, the application should also utilize the available sensors within the device, which can thereby possibly be used to confirm or refute, what is being self-reported.

The survey items used should be as fulfilling as possible
It is important that the designed application can be used to collect relevant data in that can be used to determine if a flow state has been achieved and/or if the user is regularly feeling motivated and has a high perceived quality of work life. Therefore, the items used in the self-reporting should be carefully considered, and based on the literature found throughout the analysis chapter above. This, however, also means that the items need to be condensed into as few items as possible, in order to not conflict with the first list item in this section about efficiency and obtrusiveness.

3
Methods

This study follows a pragmatic approach, as it's aim is to gain an understanding of some-what complex theories of mental states, and put it to practical use(Goldkuhl). Through an initial data gathering, in form of a literature review, and through en exploration into the state of the art, the main research question was formulated, and the methods for answering this question are dictated by their sensibility and practicality(Bjørner, 2015, p. 51). This chapter describes the methods used throughout this exploratory study, which attempts to answer this research question. It is divided into two parts, where Part 1 revolves around the design of a QWL study, and Part 2 focuses on the design of a Wearable ESM application on a smart watch. The study employs a mixed-method approach as both qualitative and quantitative data was collected and analysed. The participants were selected through convenience sampling, as there were several limitations present, which were brought on by COVID-19 restrictions, and physical access to people was scarce. For the same reason, a manual ESM study and a focus group interview, which will be described in further detail in this chapter, was conducted remotely through online tools.

3.1 Part 1: Quality of work life

This part of the study describes the methods used in order to measure a perceived quality of work life. Firstly, it will be described how a QWL questionnaire was constructed, after which a manual ESM study will be described.

3.1.1 Coding of QWL in relation to motivation and SDT

This section attempts to code the QWL factors(See section 2.3), through traditional coding practices(Bjørner, 2015, p. 98), in an attempt to categorize, how they relate to motivation and SDT(See section 2.4). This coding will be used for a QWL Questionnaire, which will be further explained in the following section.

Adequate and fair Compensation(See item 1) relates to monetary compensation(Afroz, 2018), which can be viewed as an extrinsically oriented factor(Deci and Ryan, 2013, p. 48).

Opportunities for Growth(See item 2) can be viewed as an intrinsically oriented factor due to it being related to career development and training(Afroz, 2018), which arguably falls, within the psychological need of *competence*.

Safe & Healthy Working Condition(See item 3) will here be considered to be an extrinsic controlling dimension as it revolves around the external physical working environment, and no research was obtained, that ties safe and healthy physical surroundings to intrinsic motivation.

Social integration & Cohesiveness(See item 4) directly relates to the psychological need of *relatedness*, and is regarded as an intrinsic motivator.

Work & Total Life space(See item 5) relates to the balance between work life and the life outside of work(Afroz, 2018). It will here be categorized as both extrinsic and intrinsic motivation. The reason for this duality is that one can be negatively affected or stressed out due to circumstances outside of work, which will make an employee preoccupied with personal issues(Csikszentmihalyi, 1997, p. 28). However, it does also relate to the flexibility and freedom to control ones time, rendering it an autonomous factor.

Supervisor(See item 6) is as previously mentioned a factor, which is dependent on the orientation of the supervisor. It is an extrinsic motivator, which can either be controlled or autonomous(Deci and Ryan, 2013, p. 302-303).

Human Progress Capacities(See item 7) is, similar to item 2, an intrinsic/autonomous motivational factor as it relates to developing *competence*(Afroz, 2018).

Constitutionalism, Justice and Equity(See item 8) can be classified as extrinsic as it refers to external conditions in the work environment(Afroz, 2018).

Rewards and Recognition(See item 9) is generally an extrinsic factor. However, as previously mentioned, if rewards are structured and perceived informational, they can work towards preserving intrinsic motivation.

Job Security(See item 10) is related to external factors, which the employees are not necessarily able to control, and therefore will be regarded as an extrinsic factor.

Autonomy & control at work(See item11) is intrinsic, as it relates directly to the psychological need of *autonomy*.

Participation in decision-making(See item 12) is similarly an intrinsic factor as it also relates to *autonomy*.

Communication(See item 13) can also be classified as an intrinsic factor as it relates to *relatedness*.

A table of the coded QWL factors in relation to SDT can be found in Table .1 in Appendix A.

3.1.2 QWL Questionnaire

In the literature review conducted by Afroz (2018), a ranked list of QWL factors, according to the number of occurrences in the collected literature, was defined. However, the list might be ranked differently, if workers were to rank them according to their own priorities. Therefore a questionnaire was created using Google Forms, in which the responders(n=45) were presented with all 13 QWL factors, and were asked to rate, how much each individual factor was prioritised in their own work life. The questionnaire also contained demographic information, such as Gender, Age and type of work, in order to determine if there were gender based, generational or job type differences in how people prioritized these factors. The age item was multiple choice, and contained intervals, which divided the responders into generational labels[1]. The questionnaire was distributed through the researcher's own social media network using Facebook and LinkedIn. The accompanying message for the questionnaire, which was shared on these platforms can be seen in Appendix B.

3.1.3 Manual ESM study

A manual ESM(mESM) study was conducted over a 2 week period(10 work days)[2] with participants(n=4), who was normally employed in an open office environment at the danish bank Nykredit. Although, throughout this study all the participant were working from home due to COVID-19 restrictions.

Using Google Forms a questionnaire, consisting of 12 items, was created, and the Microsoft Teams chat was used for signaling the participants. These items were constructed as scales ranging from 0-10(Not at all - Extremely), and contained statements related to flow and motivation. These questionnaire items will be described in more detail in the following design chapter, along with the considerations that went into them.

The participants were all signaled at the same time *semi-randomly* based on the researchers own temperament and judgement, which is why it is referred to as a manual ESM study. Participants of this test were signalled 2-3 times every work day between 9:45am - 3:41pm. The signal message, which was sent out each time, was formulated as such(See appendix C for the original danish translation):

> *"ESM SIGNAL!*
> *Respond to the form based on the specific activity, you undertook at the time of the signal: *SURVEY URL**
> *Remember to use your uniquely generated participant ID.*
> *Signal lifetime: 1 hour from the time of the signal.*
> *N.B.: If you are not able to react to the signal within it's lifetime, you can ignore it, and await coming signals."*

[1] Generations defined by name, birth year and ages in 2021: https://www.beresfordresearch.com/age-range-by-generation/ (visited on 13-04-2021)

[2] The ESM study was conducted from April 12 - April 23 2021, during a period, which was still affected by danish COVID-19 restrictions.

Since the chat in Microsoft Teams was used to signal participants, the 1-hour signal lifetime, was automatically indicated in the group chat thread, which was specifically created for the study, and the participants were, therefore, able to see, if they were still within the signal lifetime, when they chose to react. It was decided that a minimum of 2 hours should pass between each signal. This was, however, not a completely strict interval, but was, at all times, kept in consideration.

It was decided to keep the participants anonymous for the researcher, due to the low number of participants, and due to all of the participants being colleagues of the researcher. Therefore, in order to eliminate familiarity bias and to provide participants with an opportunity to respond honestly, it was kept anonymous. However, in order to keep track of each individual participant over a period of 2 weeks, the participants were, during a pre-test meeting, asked to privately generate a unique ID, which would serve as their identification throughout the test period. A small web-based ID generator was developed[3], which consisted of a small form. In this form the participants were asked to input a single letter, a number between 1-1000, a color, and an animal. It was believed that there was an almost non-existent chance of generating the same ID for multiple participants by providing these four inputs. The generator combined all the inputs into a single UPPERCASE string and cleaned it up for consistency by removing white spaces. Here is an example of what a generated ID could look like: *Y501BLACKPARROT*. Upon clicking on the generate button, after filling in the form, there was an option to either copy the ID to the clipboard and save it manually in a chosen document, or to directly save a TXT file containing the generated ID. During the pre-test meeting, the participants were instructed in, how to use the ID generator.

Moreover, during the pre-test meeting, the participants were presented to the ESM questionnaire and all the items. The reason for this walk-through was to provide the participants an opportunity to ask questions and clarify, in case there was any doubt about the meaning of any of the items. The test was, however, slightly, modified on the weekend before the test due to input from the participants, the project supervisor and a third person affiliated with Aalborg University with questionnaire experience. Therefore, during a morning meeting on the first day of the test, the questionnaire was again looked through by the participants.

One of the items in the questionnaire was about the social aspect of work. Here, the participants were asked to type the amount of people, they were currently socializing with. Since they all worked, and responded from home, they were instructed to only type in work related numbers. For example, if they were in work related online meetings, and not if their child, wife, husband, dog etc. walked in the room. They were told to type in 0 if they were working alone and not socializing with anyone at all.

[3]URL of the ID generator form: http://gaardbodigital.dk/ (visited on 23-05-2021)

Post study focus group

An online post study focus group meeting was held, between the researcher and the participants, on 10-05-2021, over Microsoft Teams. The aim of the meeting was to evaluate, how the mESM test had been experienced by the participants, and also to clarify some post-test questions, which may have arisen during analysis of the data(Bjørner, 2015, p. 73). Since each individual participant was still anonymous to the researcher the discussion was kept at a general and non-specific level. As a preparation for the post study focus group meeting, the participants were also asked to prioritize the QWL factors through an isolated QWL questionnaire, which was a copy of the questionnaire mentioned in subsection 3.1.2. The results from this isolated QWL responses, were used in order to spark a conversation about the working conditions in Nykredit.

Flow questionnaire

After the Post study focus group, where participants were also introduced to the study, and the term *Flow*, and what it consisted of, they were asked to respond to a small questionnaire, containing 3 items revolving around *Flow*. They were asked to rate the 3 items on a scale from 1-5, all of which were labeled from *Never* to *Constantly*. The items of the questionnaire were:

1. I regularly experience Flow in my job at Nykredit
2. I experienced Flow during the ESM test period
3. I sometimes responded to ESM signals during Flow

The goal of this questionnaire was to confirm the presence of potentially detected *flow* occurrences during analysis of the mESM data.

3.2 Part 2: Wearable ESM design

The second part of the study focuses on designing and developing a Smart watch application, which can potentially be used for data collection. The aim here was to utilize the knowledge found in part 1, and apply it to a Smart watch application.

3.2.1 Interaction design

The process used for designing the Wearable ESM application, followed a standard interaction design approach of 4 steps. Establishing requirements, designing alternatives, prototyping, and evaluating. These steps are usually meant to be repeated in multiple iterations, however, due to the small scope of this project, only an initial iteration was conducted(Preece et al., 2015, p. 15).

3.2.2 Low fidelity web-based prototype

An initial low fidelity prototype was developed, using an online tool called Proto.io[4]. The prototype primarily served as a sketching tool by the researcher, for inspiration on, how to design an ESM application for a circular smart watch interface. The prototype was not properly tested on any end users, but was a point of discussion during another similar project, which the researcher was involved in simultaneously with the present study. The other project revolved around measuring QWL on operators working at a branch of a large medicinal production company. The other project also involved the current study's supervisor, and other researchers.

3.2.3 System Usability Scale

A small first iteration Usability test was conducted with 2 participants. Due to the simplicity and repetitive nature of the application, and due to the continued COVID-19 restrictions, and the hygienic issues and a difficulty in meeting test participants, only these 2 participants were included in the test. One of the participants, was used to interacting with a Smart Watch, and used one regularly, while the second participant had no experience with Smart Watches, and never wore any type of watch, Smart or otherwise. Ideally one would have around 5 participants, for this type of test, as this is often the turning point, where the Usability problems, found by participants, start to repeat themselves(Nielsen and Landauer, 1993). Furthermore, under proper conditions, and in a longer study, multiple Usability tests, would ideally be conducted across multiple iterations in order to eliminate as many Usability issues as possible. The researcher made sure to have a recent negative COVID-19 test, and also to sterilize the watch and hands before, between, and after each participant, in order to be safe, and make the participants comfortable with wearing the watch. It was previously considered to conduct a virtual online test, however, due to the application being on a watch, with a rotary bezel, which was utilized in the present study, the physical interaction was considered to be a large part of using the application. The test was conducted during an afternoon visit to the 2 participants on Amager, on May 11th 2021, and after the test, the participants, were asked to fill out a System Usability Scale questionnaire[5]. The first item in the SUS scale was reworded in order to make it more applicable to the context, in which it was supposed to be used. The original wording of the item was: "I think that I would like to use this application frequently.". This item was changed to: "I think that I would frequently be able to respond via this application during my workday.". The participants were in the beginning of the test, presented with an hypothetical scenario, in which their current workplace was involved in a study, where each employee was given a smart watch. They were told that the watch would randomly vibrate, and when it did, they should respond to the signal. The goal of this hypothetical scenario, was to mentally place them in the context in which the application would ideally be used.

[4]Proto.io website URL: https://proto.io/ (visited on: 12-05-2021)

[5]Usability.gov website for System Usability Scale: https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html (visited on: 11-05-2021)

4
Design

This chapter will describe the design process of the mESM questionnaire, which constitutes the first part of the study. It explains the considerations, that went into designing a fulfilling data gathering on a device, which is limited by it's interaction and size. Moreover, the initial design iteration of the Wearable ESM application, will be presented from the initial low fidelity prototype, to the final prototype, which was also affected by the Usability test conducted.

4.1 Part 1: Perceived quality of work life

This section describes the considerations that went into designing the items that went into the ESM questionnaire, and the wording of these. The questionnaire was created using Google Forms in order to run a ESM study on multiple participants, without access to a Samsung Smart Watch. It was, however, always carefully considered, how each item would translate onto the small screen of the watch, and the data gathered through Google Forms, should be as similar as possible to the data, that would potentially be submitted from a smart watch.

4.1.1 Questionnaire header

In order for the participants to understand how the scale should be used, an explanatory header text was added in the beginning of the form. This text can be seen below:

> ***How is your current mental state as you are being signaled? (Rate you level of agreement)***
> *This scale is used:*
> *0=Not at all*
> *10=Extremely - is compared to your OWN most extreme experience of that question.*
> *For example in the first question: "I'm currently preoccupied with circumstances outside of work":*
> *Answering "Extremely" here means that you have never been more preoccupied with circumstances outside of work than you are right now.*

The scale used for all items was inspired by the Visual-analogue scale(VAS), often used to measure subjective pain in patients suffering from various deceases. One exception was an item, which counted people currently being socialized with. The

scale ranged from 0-10[1], in order to provide a way for participants to respond in a nuanced manner(Kos et al., 2017). This also means, that a top rating of 10, would be an absolute maximum response, whereas 0 indicated an absolute minimum.

4.1.2 Questionnaire items

The questionnaire items were worded in a first person perspective, in an attempt to make them personal to the respondent. The below list shows the items used in the mESM study, following the list is an explanation for choosing these items:

1 I'm currently preoccupied with circumstances outside of work *(Elimination)*
2 I'm currently feeling stressed *(Flow)*
3 I feel like time passes by fast *(Flow)*
4 I feel challenged by this activity *(Flow, SDT)*
5 I feel skilled in this activity *(Flow, SDT)*
6 I feel concentrated on this activity *(Flow)*
7 I feel like I'm in control of the outcome of this activity *(Flow, SDT)*
8 I currently feel confident in general *(Flow)*
9 I am currently feeling happy *(Valence)*
10 I am currently motivated to continue working *(SDT)*
11 I'm currently fond of my job *(QWL)*
12 I am currently with other people (How many? Write a number. 0 if your are alone) *(SDT)*

Item 1 in the list above, was used as an elimination item. Since the study was aimed at measuring the participant's state of mind during work, this item could potentially be used to dismiss the response if this item was rated high. Items 2-8 are related to *flow* states. If a high level of stress is reported, the probability of a flow state to be present is decreased(See section 2.3). Time distortion, challenge, skill, concentration, control and confidence relate to flow, and a high rating of these items, could potentially mean that *flow* has been reached, provided that the remaining items also align with the *flow* state. Items 4,5,7,10 and 12 relate to motivation and self determination. Some of the items in the above list are also overlapping. For example item 5 about skills are both part of reaching a flow state, if the level of challenge is also high, or slightly higher, however, it also relates to the *Competence* need of SDT. As is the case with item 7, which falls into the psychological need of *Autonomy* and being in control, which is also a condition associated with *flow*. The last item of the list, Item 12, determines if the participant was with other people during the response. It relates to the need of *Relatedness* according to SDT. Item 9, is used to determine the valence experienced by the participants, and if the ongoing activity evokes negative or a positive emotions. Finally, item 11, is a way of determining, whether the specific activity, the participant was undergoing, during the response, heightened or lowered the fondness towards the job. In the original ESM studies, conducted by Csikszentmihalyi (2008), which used notebooks, participants wrote

[1]Very well health article on pain scales: https://www.verywellhealth.com/pain-scales-assessment-tools-4020329 (visited on: 14-05-2021)

down what they were doing at the time of the signal(See section 2.6). However, since text input is not an ideal type of input on a smart watch, this item was an attempt to get a sense of, how different work tasks affected the participant, without the specificity of the activity.

4.2 Part 2: Wearable ESM design

In this section the design process for the Wearable ESM application prototype, and the decisions made at various stages, will be described.

4.2.1 First sketch

Early in the design process a sketch was made on a whiteboard. Due to the researcher's lack of experience in designing for small circular touch screens, and also the lack of experience with interacting with such a device, the design process was unfamiliar territory. This was evident in the earlier prototype designs, as there was little consideration about, how to properly interact with a Smart watch. In later stages of the project, the design process and the Implementation phase(Described in more detail in the following chapter) began to overlap, as this made it possible to physically test changes in the design using a trial and error approach. The first sketch of the prototype can be seen in Figure 4.1 below.

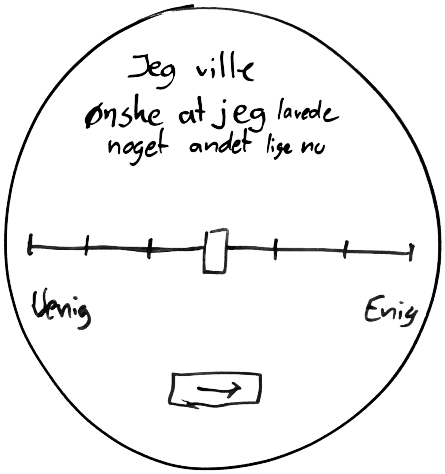

Figure 4.1: Early sketch of the prototype design.

4.2.2 Initial design ideas

As previously mentioned in subsection 3.2.2, an early web based prototype was developed using an online prototyping tool. This initial design was a continuation of the initial sketch, and included computer screen based interactions. At this stage there was little focus on the survey items and the wording of these. In Figure 4.2 below, a selection of the screens from the prototype can be seen. A working prototype can be found in the digital appendix.

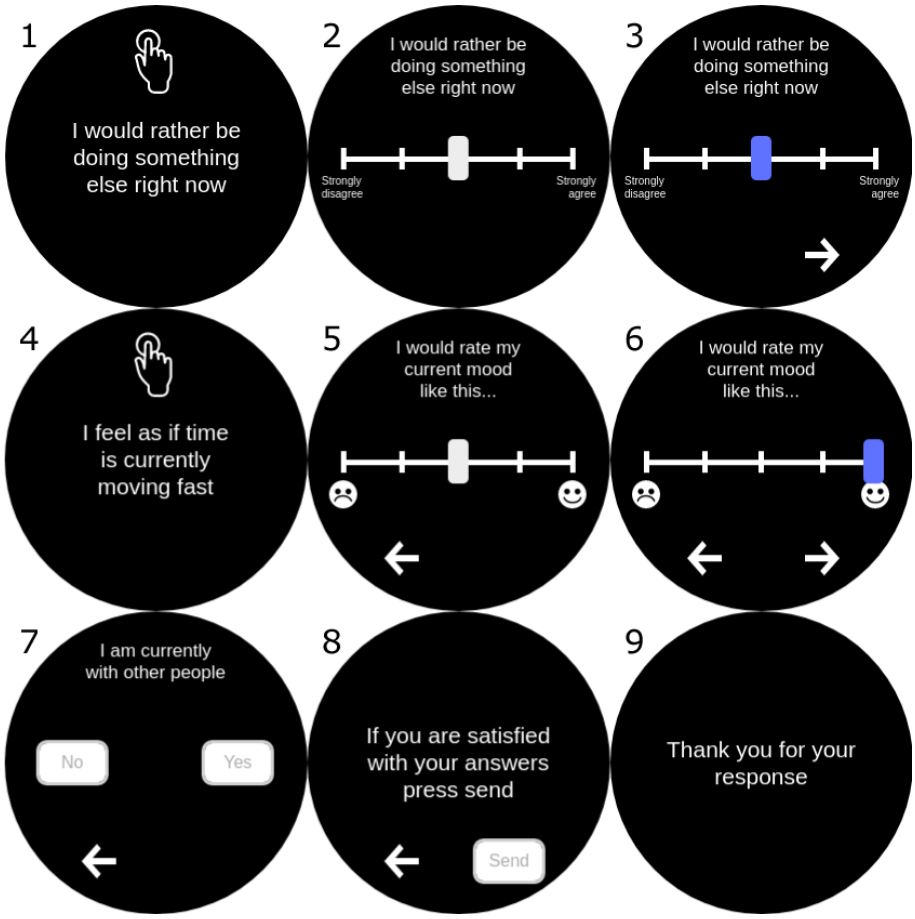

Figure 4.2: Collection of screenshots from the initial low fidelity prototype, made using the online tool Proto.io.

Initially all the user interaction was touch based, as the idea of utilizing the rotary bezel of the Samsung Galaxy Watch, was not realized at this point. Number 1 and 4 in Figure 4.2, shows the first screen for each of the items, it requires the user to tab the screen in order to respond to the item. On this screen the font size of the item was meant to be larger on screen, and after the user tapped the text would decrease in size and move to the top of the screen, as a slider would appear (See number 2 and 5 in Figure 4.2). Only after the slider would be interacted with, a *Next* arrow icon would appear in the bottom of the screen(See number 3 and 6 in Figure 4.2). In order to force the user to consider each item, it was not a possibility to continue, until the slider was activated. This ensured that a user could not tap all the way through the application without considering, how to rate their state of mind, leaving data points for the researcher, that were all neutrally rated every time. As can be seen in image Number 3 in Figure 4.2, it was still a possibility to rate the item neutrally, but this required an activation of the slider. The *Back* arrow button was always visible to make it possible to change a previous response.

4.2.3 First design

As previously mentioned, the rotary bezel on the Smart watch, was not utilized until the implementation phase of the application commenced. This played a large part in the design changes from the initial to the final design. Figure 4.3 shows the final design before conducting the Usability test.

Figure 4.3: Collection of screenshots from the first design iteration, before the Usability test was conducted. The screenshots are taken using the Tizen Emulator, which can be installed through Tizen Studio.

Tutorial screen

Once the application was started it was important to make sure that users would think outside the screen, and use the rotary bezel in order to change values for each item. Therefore, a timed animated tutorial screen was added to the initial item, which would appear after 5 seconds. This tutorial screen consisted of 2 double ended arrows, which would rotate back and fourth, while an accompanying text was display in the center of the screen. The text stated: "Use the rotary bezel to change values", and would appear, alongside the animated arrows, after 5 seconds where no interaction had been detected. Once the user would either rotate the bezel, and thereby change value, or tap the touch screen, the tutorial would fade out. The tutorial screen can be seen in image number 1 of Figure 4.3.

Main item screen

Once the user would rotate the bezel, after seeing the tutorial, a small dot indicator, which started at the top center of the screen would move according to the direction, in which the user would move the bezel. A circle shaped bar indicating the track of the range bar was colored in from the bottom of the bar to the current value, where the small dot indicator was located. The remainder of the bar was colored in grey indicating how far the dot could go. This can be seen in the images labeled 2-4 in the above Figure 4.3.

Colors

It was decided to add a color change to the circular bar, and the accompanying value label, which gradually changed, from red to green, depending on the chosen value. When the chosen value was low, the bar and the label was red, and these would both

become more green as the values increased. The reason for adding this gradually changing color effect, was to provide the user with another subtle indicator of where the chosen value was located on the full scale. Since the application was meant to be used repetitively, the aim of this color change was, for the user, to be able to rank the items through colors, as well as the dot indicator and accompanying label, showed in the bottom of the screen, and therefore could potentially respond more rapidly in each response. In Figure 4.3 this color change effect can be seen in images number 2-4 where the colors change from red to green respectively depending of the chosen value.

Progress bar

In image number 5 in Figure 4.3 a white circular line can be seen besides the range track. This line is not visible in any of the other images in the figure, as it is only a temporarily visible progress bar, which would only appear between every item to indicate the users progress in the total response. After responding to an item and tapping on the next button, the progress bar would appear for a second, and become slightly longer, through a small animation, to indicate how far the user was in completing the total questionnaire. This progress bar was added as an inspiration from the LinkedIn progress bar(See subsection 2.5.1), to entice the user to complete the entire questionnaire every time.

Arrows

It was decided to make an interaction mandatory, as seen in the earlier designs, in order for the user to continue with the questionnaire. Therefore, the *Next* and *Previous* arrows would only appear after the user had made a change in value, forcing the user to make a decision in order to move on or go back. Therefore, in order to select a neutral value, the user would have to rotate the bezel one step, in either direction, and back.

4.3 Summary

This chapter has described the design process, that went into designing the questionnaire, and the considerations, that went into choosing all the items. Moreover, it described how the smart watch application it self was designed. However, as previously mentioned, this design process did, along the way, merge with the implementation phase, which will be described in the following chapter. The reason being the convenience in testing the design on a physical watch, as this made it easier to adjust the design, according to the interaction types afforded by the smart watch.

5
Implementation

This chapter describes the implementation process of the Wearable ESM application, developed for the Samsung Galaxy Watch 3. In the chapter a few of the main functionalities will be highlighted and explained. Furthermore, the chapter describes the implementation of an online database and administration frontend, which is used for gathering and displaying the data collected from the Wearable ESM responses.

5.1 Wearable ESM application

As mentioned above the application was developed using the 45mm Samsung Galaxy Watch 3(Bluetooth)[1] as a debugging/testing device. This watch is operated by Tizen 5.5. Development of Tizen application is done through Tizen Studio, which is an integrated development environment(IDE), used to code and deploy applications onto either a desktop Emulator or a physical device. It was developed using web languages(HTML/CSS/JS), rather than the native C/C++ languages, as web technologies were preferred by the researcher, due to prior experience. The Samsung Galaxy Watch 3 is a smart watch, and can be interacted with through the circular touch screen, two physical buttons, and a rotary bezel, which can be used to scroll between menus, lists, apps, long text passages etc.

5.1.1 Flow chart

The application is running as a single page application, consisting of 3 sub-pages. A start sub-page, which contains a small introductory text, an item sub-page, which cycles through all the items, and a submit sub-page, for submitting the response. An overview, of how a user progresses through the application, can be seen in Figure 5.1 below.

[1]Official Samsung website displaying the 45mm Samsung Galaxy Watch 3(Bluetooth): https://www.samsung.com/dk/watches/galaxy-watch/galaxy-watch3-bluetooth-45mm-mysticblack-bluetooth-sm-r840nzkaeud/ (visited on: 19-05-2021)

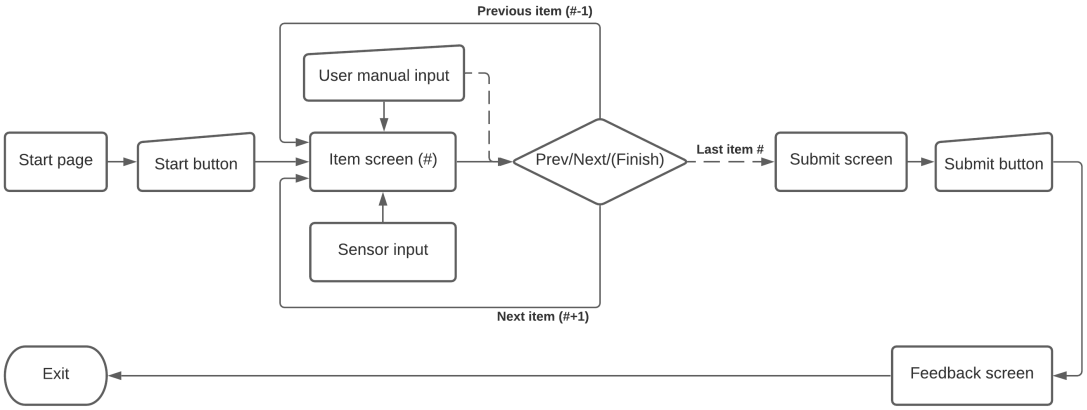

Figure 5.1: Flow chart of the Smart Watch ESM application.

5.1.2 Sensor permissions

In order to be able to obtain sensor data, while the user responds to the ESM questionnaire, the user needs to grant the smart watch application access to read from it's Human Activity Monitor(HAM). On the first run, the application asks the user for permission to use the so-called *healthinfo* privilege, which is required in order to measure the users heart rate and RR-interval. These measurements will be described in a later section of this chapter.

5.1.3 Tutorial

In the first image of Figure 4.3 in chapter 4, the tutorial screen can be seen. This tutorial uses a JavaScript based delay, which makes it appear, if there has been no interaction within 5 seconds of starting the Wearable ESM survey. A listing showing the code for showing the tutorial can be seen below in Listing 1.

```
rotaryEventHandler = function(e) {
    [...]
    $('.tutorial').addClass('hidden');
    clearInterval(tutorialInterval);
    clearTimeout(tutorialTimeout);
    [...]
}

tutorialInterval = setInterval(function(){
    if(dataPage.hasClass('data-page') && tutorialTimeout === null){
        tutorialTimeout = setTimeout(function(){
            $(document).find('.tutorial').removeClass('hidden');
            clearInterval(tutorialInterval);
            tutorialInterval = null;
        }, 5000);
    }
}, 500);
```

Listing 1: Listing showing the timed tutorial. Upon openening the application a half second interval will constantly check if the the questionnaire has started. If this is the case, a 5 second timer will start, and if no interaction has been detected on the rotary bezel within the 5 seconds, the tutorial will appear.

As the above listing shows, a `hidden` class is added or removed on the tutorial element in the document object model(DOM), using built-in jQuery methods `addClass()` and `removeClass()` respectively. The `hidden` class is predefined in the main CSS file, and changes the elements opacity to 0. When the tutorial appears and disappears this opacity will undergo a transition, so the visibility of the element smoothly appears or disappears. The animation of the 2 double ended arrows, inside the tutorial element, uses CSS3 animation, which can be seen in Listing 2 below:

```
.tutorial:before{
    [...]
    animation:spin 6s ease-in-out infinite;
}

@keyframes spin {
    50% {
        transform: rotate(180deg);
        }
    100% {
        transform: rotate(-180deg);
    }
}
```

Listing 2: Listing showing how the arrows in the tutorial continuously spin back and fourth using the CSS3 animation property.

As Listing 2 shows, the animation keyframes are defined through percentages, and

the **rotate** transform makes the arrows spin back and fourth in an endless loop, defined by the **infinite** property in line 3.

5.1.4 Circular scale

The range slider input, where users were to rate each of the items, was created using a jQuery based plugin called RoundSlider[2]. When building a Web Application for a Tizen based Smart Watch, there is a possibility of using built-in UI components through the Tizen Advanced UI(TAU) library[3]. However, in order to retain complete control of styling and functionality, it was decided to use the external RoundSlider plugin. In order to tap into the rotary bezel interaction and connect the changes in it to the round slider, a method was defined, which can be seen in Listing 3 below.

```
1  function rotaryEventHandler(e) {
2      var prevVal;
3      [...]
4      if (e.detail.direction === 'CW') {
5          /* Right direction */
6          prevVal = slider.roundSlider("getValue");
7          slider.roundSlider("setValue" , (prevVal+1));
8      } else if (e.detail.direction === 'CCW') {
9          /* Left direction */
10         prevVal = slider.roundSlider("getValue");
11         slider.roundSlider("setValue" , (prevVal-1));
12     }
13     [...]
14 }
```

Listing 3: Listing showing how the rotary bezel events are triggered and how, as a result of this, the value changes in the circular range slider.

The rotary event is also responsible for showing and hiding the *Previous* and *Next* arrows, by either adding or removing the **hidden** class, from the DOM element of these arrows. A `ColorManager` class was created, which handles the color change on the range slider depending on it's current value. The `ColorManager` receives a DOM element, which will be affected by the color change. It also receives the current value of the range slider input, and an argument, defining if the color change should affect a background color or a text color. The former, changes the color of the slider track, whereas the latter changes the text color of the label indicators, which corresponds to the value of the slider. These labels are for example: *Not at all*, *Mildly*, *Severely*, *Completely*, *1 person*, *2 people* etc.

[2]Url for the jQuery round slider plugin: https://roundsliderui.com/ (visited on: 20-05-2021)

[3]TAU documentation page: https://docs.tizen.org/application/web/guides/tau/tau/ (visited on: 20-05-2021)

```
//main.js
colorManager.updateColor(
    $(document).find('.indicator'),
    slider.roundSlider("getValue"),
    'text'
);
colorManager.updateColor(
    $(document).find('.rs-range-color'),
    slider.roundSlider("getValue"),
    'background'
);

//ColorManager.js
updateColor(element, val, type){
    this.clearColorClasses(element);
    if(type === 'text'){
        element.addClass(this.getTextColorClass(val));
    } else if(type === 'background'){
        element.addClass(this.getBGColorClass(val));
    }
}
```

Listing 4: Listing showing how the ColorManager class handles color change on an element.

5.1.5 AJAX post

On each run, the application collects the users self-reported responses, through a `ResponseHandler`. This class is responsible for gathering all the data, by keeping track of each item and the corresponding user inputs for these. Furthermore, the class keeps track of the timestamp of when the user starts responding, and also the timestamp of when the form is submitted. This is used to measure, how long time each response takes. During each response, the heart rate sensor is continuously measuring the user's heart rate as well as RR-intervals. These measurements are added into two separate arrays, which are handled by a `HRHandler` class. When the user submits the form, all of these data are collected into a javascript object, that is converted into a JSON string(JavaScript Object Notation). The data object is hereafter posted to a database, through AJAX(Asynchronous JavaScript And XML), which can be used to post data to a remote server. This post process can be seen in Listing 5 below.

```
//main.js
$(document).on('click', '#submit', function(){
    var dataObj = {
        'self': responses.getAllResponses(),
        'hr': hrHandler.getHR(),
        'rr':hrHandler.getRR(),
        'duration':responses.getDuration(),
        'start':responses.getStartUnixTimestamp(),
        'end':responses.getEndUnixTimestamp(),
    };
    var data = {
        'data' : dataObj
    };
    $.ajax({
        type: "POST",
        url: "https://gaardbodigital.dk/dbwrite.php",
        data: JSON.stringify(data),
        success: function(resp){
            resetApp();
        }
    });
});
//dbWrite.php on remote server
try {
    $sql = "INSERT INTO `esm_data` (`data`) VALUES ('$data')";
    $result = $conn->query($sql);
    echo 'Inserted succesfully';
} catch(exception $e) {
    echo "ex: ".$e;
}
```

Listing 5: Listing showing how the data is posted to a remote server using AJAX. The data is posted to a MySQL database using a php-file, which is located on the server, and handles the insertion of the data into the database.

5.2 Web based data analysis tool

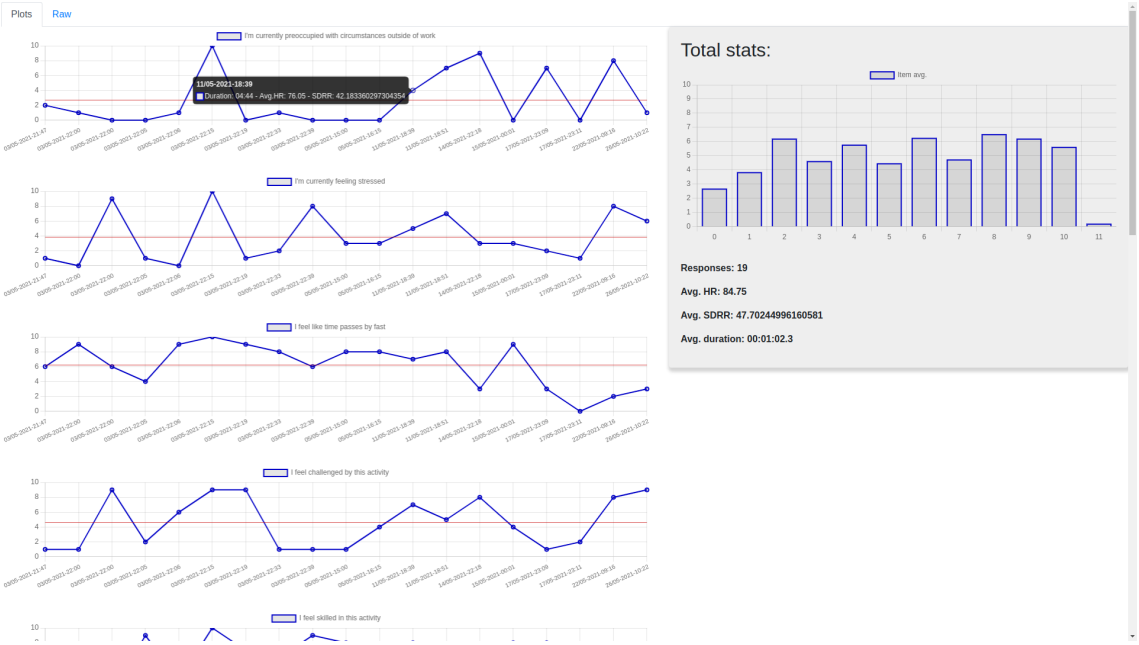

Figure 5.2: Screenshot of the data analysis tool. *Note: The displayed data in the screenshot is arbitrary testing data, which was captured during testing of the smart watch application.*

On the remote server, a web based data analysis tool was developed[4]. Figure 5.2 is a screenshot from this tool. On the left hand side of the figure each individual item is presented on a line chart. The division of the items, into individual charts, provides a timeline, which makes it possible to track individual changes in time. The mean response is indicated by the red horizontal line in each line chart. On the right hand side a bar chart shows the total mean responses for each item. Furthermore, additional response count, time- and heart sensor related data is displayed.

5.2.1 Data visualization

A javascript based library called Chart.js was used to display the data from the database[5]. The library uses the HTML5 canvas element, which is used to draw graphics in HTML. This library made it possible to quickly create animated graphs, which can also be interacted with. When hovering over a single input, with the computer mouse, in any of the line charts, a tooltip appears displaying details on the specific response.

[4]The online data analysis tool can be accessed through this URL: `http://gaardbodigital.dk/admin/` (visited on: 20-05-2021)

[5]Chart.js website: `https://www.chartjs.org/` (visited on 20-05-2021)

5.2.2 Measuring stress using HRV

Since the smart watch used in this project was running on Tizen 5.5, it was unfortunately discovered, on a late stage, that the direct access to the STRESS_MONITOR was a deprecated functionality on this version of Tizen[6]. Therefore, there was a need to explore alternatives in measuring stress, through the heart rate sensor using the RR-interval, which is the time interval between peaks in the heart rate, and is still accessible through the sensor in the watch. By using the RR-interval it is possible to calculate the Heart Rate Variability(HRV), through various methods either in the time-domain or in the frequency domain, which can be used to determine a person's sympathetic- or parasympathetic nervous system activity(Kim et al., 2018). A simple way of calculating HRV is by a method called SDRR, which stands for standard deviation of RR-intervals(Shaffer and Ginsberg, 2017). Due to the short term usage of the application, the RR-interval readings contain very little data, which compromises the accuracy. Furthermore, SDRR is noisy, compared to the alternative SDNN, which filters the RR-interval data through various artifact correction methods(Rincon Soler et al., 2018). Due to the scope of this project, the topic of HRV, was not prioritized and explored in depth, as this topic is a field of it's own. However, it was ensured that the application collected the RR-interval data, and as an example the SDRR calculation was performed an is displayed on the remote server analysis tool. This calculation can be seen below along with Listing 6, which is the calculation performed in JavaScript.

$$s = \sqrt{\frac{\sum(x_i - \overline{x})^2}{n-1}}$$

```
1  //Reusable method for calculating means of an array
2  let arrayAverage = (arr, len) => arr.reduce((sum, x) => x + sum, 0) / len;
3
4  //Calculate the mean RR
5  let averageRR = arrayAverage(this.rrList, this.rrList.length);
6
7  //Calculate the squared differences from the mean
8  let squaredDifferences = this.rrList.map(x => x - averageRR).map(x => x * x);
9
10 // Calculate the variance (Mean of all the squared differences)
11 let variance = arrayAverage(squaredDifferences, this.rrList.length-1);
12
13 // Return the square root of the variance / standard deviation
14 return Math.sqrt(variance);
```

Listing 6: Listing showing how HRV is calculated using Standard deviation of the RR-intervals(SDRR).

[6]Tizen Documentation, showing the deprecated STRESS_MONITOR: https://docs.tizen.org/application/web/api/5.5/device_api/wearable/tizen/humanactivitymonitor.html#HumanActivityStressMonitorData (visited on: 20-05-2021)

5.3 Summary

In this chapter it was described how the single page Wearable ESM application was implemented using Web based languages in Tizen Studio. The process of data collection inside the application, was explained, followed by a description of how the data was posted to a remote server for later display and analysis. It was exemplified how to potentially calculate HRV, in order to measure stress, although the current method used contains known flaws.

6
Evaluation

This chapter will describe the results from the QWL quesstionnaire, the 2-week mESM study, and the Usability test conducted during the 2 parts of this project(See chapter 3).

6.1 Part 1: Quality of work life

6.1.1 QWL questionnaire results

In order to get a sense of the worker's own QWL factor priorities, a survey was created, where respondents, were asked to rank each of the Quality of Work Life factors presented in section 2.3. This type of survey could potentially be used by workplaces in order to improve the highest prioritized factors within particular work places. For example, if a group of employees, or a specific department, would rank the social aspect(See item 4 in section 2.3) of the work place high, there might be good reason to improve this aspect of the work environment. Furthermore, if such a work place, were to implement a form of gamification into their daily work, there might be an advantage in focusing on the social factor of gamification(See item 5 in subsection 2.5.1). Another example is, if employees were to prioritize Rewards and Recognition(See item 9 in section 2.3), there might me a potential in focusing on the PBLs in regards to gamification(See item 2 in subsection 2.5.1).
Due to the test being distributed through the researcher's own social media network, there was a predominantly larger response rate by people working in an office environment. The reason for this was, that the researcher's past work/educational, and therefore social, background, contained people within this environment. This resulted in responses by non-office workers being very low. It was therefore decided to demographically divide all the work type responses into two groups, which consisted of office workers and non-office workers, regardless of the broad span of non-office workers participating in the survey. In order to target specific work types, this type of survey, should be directed towards the job type of interest. The total responses from the QWL questionnaire can be seen in Figure 6.1 below. A collection of plots from the questionnaire, divided into different demographic groups, can be found in Appendix D.

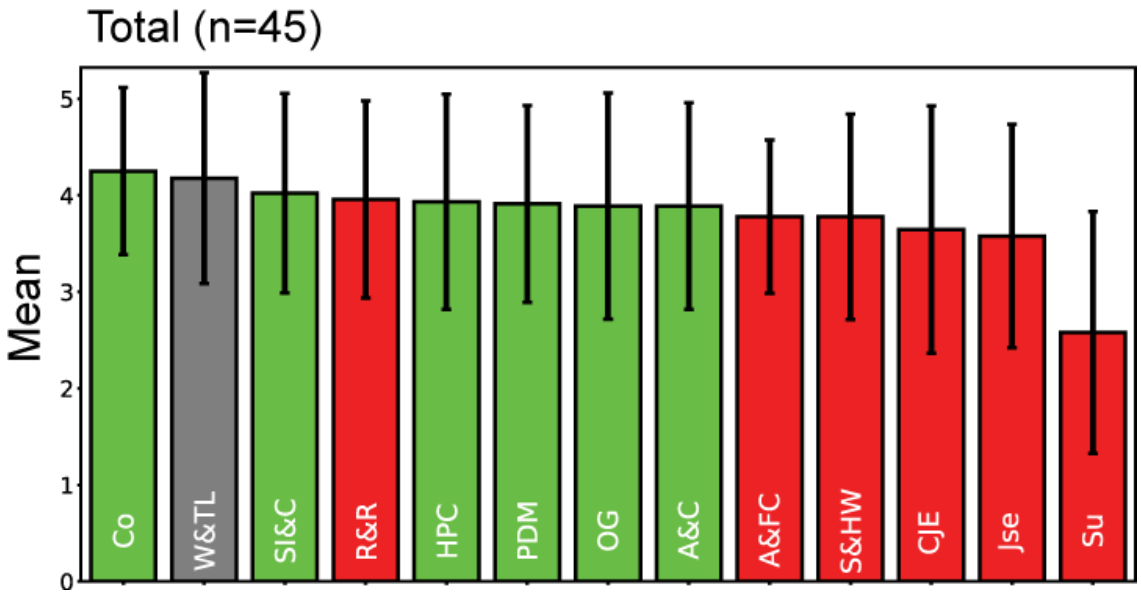

Figure 6.1: Bar chart showing the total responses to the QWL questionnaire. Green bars signify intrinsically motivated factors, whereas Red bars signify extrinsic. The grey bar signifies both. Standard deviation is indicated in black on each bar. Unabbreviated factors in order: Communication, Work & Total Life space, Social integration & Cohesiveness, Rewards and Recognition, Human Progress Capacities, Participation in decision-making, Opportunities for Growth, Autonomy & control at work, Adequate and fair Compensation, Safe & Healthy Working Condition, Constitutionalism, Justice and Equity, Job Security, Supervisor.
Source: Exported as SVG from a Python based Jupyter notebook and recolored in Adobe Illustrator

In the full collection of plots(See Appendix D), it is evident that the *Supervisor* item consistently is ranked very low(See item 6 in section 2.3), and is in the bottom in 8 of the 9 grouped plots in Appendix D. According to Afroz (2018) this item relates to the behavior of a supervisor, how much social support is experienced from a supervisor, and how a supervisor in general treats the staff. This might be an indication of *Supervisor* as a term might not be common in many jobs. When starting a new job, the worker might be assigned to a supervisor responsible for onboarding the newly arrived employee, for a short period of time, until the employee can independently perform. However, this type of training situation does not last, and therefore might not be of large concern for people with work experience in general. In larger corporations there might also be a larger hierarchy of leaders, managers, or middle managers responsible for staff in various departments and teams, but whether or not the term *Supervisor*[1], was interpreted as something completely different is unknown.

Work & Total Life space(See item 5 in section 2.3) is often ranked highly. This item might have had a greater importance in times of lock-downs, and home offices, due to the COVID-19 pandemic. As the QWL questionnaire was first sent out through social networks on the 7th of April 2021, more than a year had past, since Denmark was first locked down due to the pandemic. Many jobs had been handled from home

[1]The danish translation of *Supervisor*, used in the questionnaire was *Tilsynsførende*

for about a year, which might have put extra emphasis on this item, as it relates to work life balance, and flexibility in work and family life, social responsibilities etc.

In general the bar chart in Figure 6.1 above shows, that the total responses lean towards prioritizing the intrinsically motivational factors, as they have been classified in this study, with one exception being *Rewards & Recognition*(See item 9 in section 2.3). This item relates to employees being recognized and appreciated for their efforts and tasks, through rewards and promotions.

When viewing the Male/Female divided plots in Appendix D, there seems to be more focus on intrinsic factors on the female side. However, the highest ranked extrinsic factor in the female plot is *Constitutionalism, Justice and Equity*(See item 8 in section 2.3). This item relates to work ethics, grievance handling, sexual harassment, and discrimination. The item is ranked very low on the male side, which might be a result of the increased focus on sexism and sexual harassment in work places. A focus which has been intensified through various movements, such as *#metoo*, in recent times, and is predominantly affecting women. A similar observation can be made in relation to the topic of discrimination. The respondents were primarily a sample of Caucasians, mostly males, due to the survey being distributed in Denmark, through the researchers own social network, which is, not by choice, far from being ethnically diverse. Therefore this item might not be a large concern, since the sample of mostly Caucasian males have rated it second to last.

There are many points that can be drawn from a questionnaire as this, and this section has highlighted a few of these points. Whether this type of questionnaire is widely distributed, or distributed in a smaller team or department, it might become more clear, where a focus of improvement should be placed. By collecting this type of data, a work place can potentially tailor new initiatives towards it, in order to improve the general QWL amongst the employees.

6.1.2 Manual ESM study

As previously mentioned in subsection 3.1.3 the mESM was conducted during a period of two weeks. A minimum of 2 signals were sent out every work day, however, 4 days out of the 10 days triggered 3 signals. In total 96 signals were sent out during the test period as every signal counted for 4 in total, due to all the participants being signaled at the same time.

$$24\ \textit{signals} * 4\ \textit{participants} = 96\ \textit{signals}$$

These signals resulted in a total response rate of $\approx 64,6\%$ as 62 signals spawned a reaction.

$$\frac{62\ \textit{responses}}{96\ \textit{signals}} * 100 = 64,5833\%\ \textit{response rate}$$

Originally there was 63 recorded responses in the form, however one response was

excluded, due to a copy/paste error, which resulted in a participant pasting in the URL of the survey into the unique ID field, rather than pasting in the unique participant ID. This made it impossible to know, which participant the response belonged to. Another response was also considered for exclusion, due to it being recorded 11 minutes after the 1-hour expiration of the signal. It was, however, ultimately included in order to get the most value possible out of the limited amount of data recorded. The individual response rates can be seen in Figure 6.2 below:

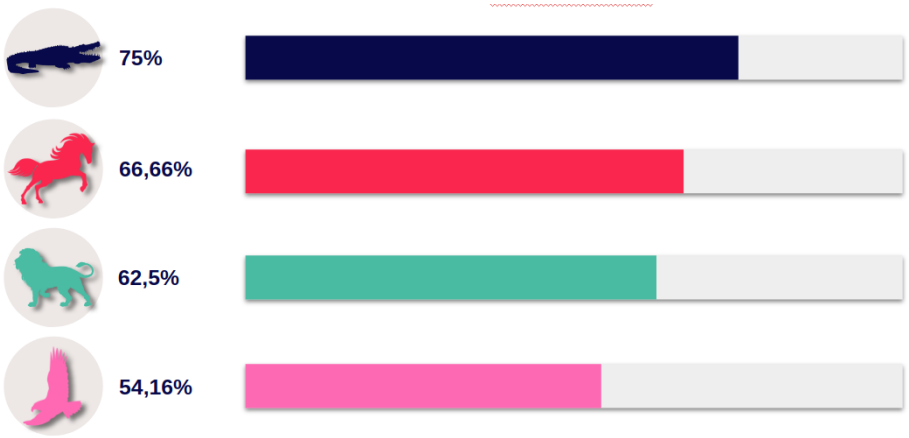

Figure 6.2: Figure showing the individual response rate by each of the participant over the 2-week period. The animal icons relate to the Unique ID generated by the participant.

A vast majority of signals(85,5%) were reacted to during solitude, meaning that there was no ongoing meetings during the response. Only 9 responses, were recorded during meetings consisting of $1-4$ people. This might be an indication of the inconvenience of the way the study was setup, as it required some effort of the respondents every time they were signaled. Ideally, participants should be able to respond at any given time.

In Appendix E all the results can be seen in stacked graphs over the full two week period. Indicated in the graphs are also potential flow experiences, the classification criteria for flow experiences, will be described in the following sub-section.

Criteria for classifying potential flow

Flow experiences require the participants to not be distracted by outside circumstances, which was the reason for adding the first elimination item to the questionnaire. If participants were distracted by anything other than the task at hand, a flow experience was not considered to be possible(See items 2 and 5 in section 2.2).

Once there is no distraction, there are a few other criteria, which need to be fulfilled, in order for a flow experience to be present. Challenge and skill level needs to be high, and ideally the skill levels needs to be just below the challenge level(See item 1 in section 2.2). However, their might be differences in the participant's understanding and interpretation of these items in the questionnaire, which is why they,

in this study, will be interpreted as fulfilled flow components if both these items are fairly high.

Items such as concentration and control of the situation should also be high, if flow is experienced(See items 5 and 6 in section 2.2). The time distortion item was added in order to confirm the presence of flow, and a high rating of this item is therefore also required(See item 8 in section 2.2).

As stress is a factor, which is destructive for the flow experience(Csikszentmihalyi, 1997, p. 106), there should ideally be a low reported stress level.

The remaining criteria for a flow experience, should be reported with a high happiness and confidence value. Furthermore, one should be motivated to continue working, and be fond you one's job.

A summation of these criteria for classifying flow in the results in Appendix section E, can be seen in the list below.

- Low distraction
- High skill and challenge
- High concentration
- High sense of control
- High sense of time moving fast
- Low stress
- High confidence
- High happiness
- High motivation
- High fondness towards the job

Even though the stress levels in several of the flow indications in Appendix E, seem to be fairly high, they were highlighted, due to the remainder of the items aligning with potential flow. Furthermore, the participants happiness and fondness towards the job, still seemed to be high, despite the reported stress. It was therefore considered a peculiar item, and needed to be discussed during the upcoming focus group meeting with the participants.

6.1.3 Post-test focus group

The focus group meeting began with a general presentation of the overall study, in order for the participants to get an understanding of the subject. Before the mESM study they had not been given a detailed description of it, in order to not affect their responses throughout. The full audio from the focus group meeting can be found in the digital appendix and throughout this sub-section, this audio file will be referred to by time code intervals(mm:ss-mm:ss). As preparation to the Post-test focus group meeting, the participants were asked to respond to an isolated version of the QWL questionnaire, in order to determine, how the 4 participants, working in the same small digital team at Nykredit, prioritized the QWL factors. This response

was recorded subsequently to the mESM test experienced by the 4 participants. The results can be seen in Figure 6.3 below.

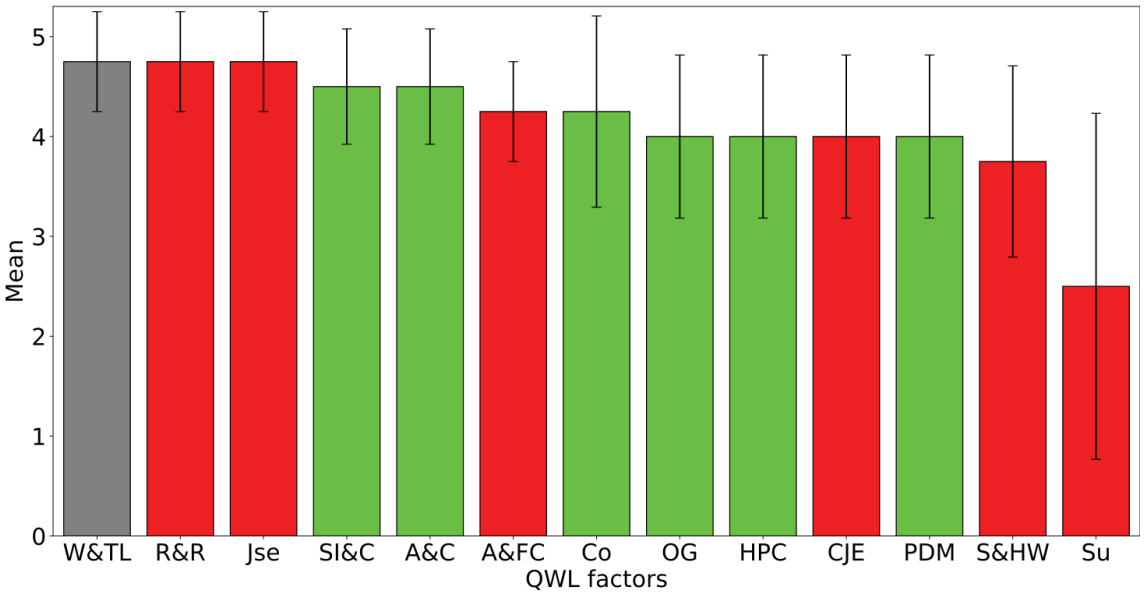

Figure 6.3: Bar chart showing the isolated ESM test group response to the QWL questionnaire. Green bars signify intrinsically motivated factors, whereas Red bars signify extrinsic. The grey bar signifies both. Standard deviation is indicated in black on each bar. Unabbreviated factors in order: Work & Total Life space, Rewards and Recognition, Job Security, Social integration & Cohesiveness, Autonomy & control at work, Adequate and fair Compensation, Communication, Opportunities for Growth, Human Progress Capacities, Constitutionalism, Justice and Equity, Participation in decision-making, Safe & Healthy Working Condition, Supervisor.
Source: Exported in colors directly as SVG from a Python based Jupyter notebook and converted to PNG

There was a discussion, revolving around specific QWL factors, in order to determine, how these factors were viewed by the participants, as they responded to the survey. This was to confirm or refute if the items were properly divided into Intrinsic or Extrinsic factors according to how they were perceived by the participants. As the above graph shows, one of the highest rated QWL factors was *Work & Total Life space*(See item 5 in section 2.3). When asked how the participants viewed this item, one participant stated(06:50-07:50):

> *"I think that my assumption of it was to what extent does the work place control my time. Partly in regards to a volume that is fair, but also in regards to the period in the 24-hour day that is fair. But also really, how much I am in control of it. How much am I in charge of... Do I take time of work between 12 and 2, because that fits in with my dentist appointment or something. That is possible in some workplaces, but if you are working at a gas station alone, then you can't close the gas station for two hours."*

Another participants also commented on the item stating that(11:28-11:52):

> *"It might be OK that it is mixed. Much of it is about the restraints that have been put together,[...] that make it possible to take care of your job as you wish, of course within reason."*

In relation to the item *Social integration & Cohesiveness*(See item 4 in section 2.3), a third participants suggested(13:20-13:28):

> *"Couldn't you also, if you wanted to, make that one grey? I guess that it too is about some structures and a culture created by Nykredit."*

When asked about the item *Rewards and Recognition*(See item 9 in section 2.3), the participants seem to agree about the importance of recognition, however, the conversation quickly moved to salary, which might be an indication of a misunderstanding as salary has more to do with the *Adequate and fair Compensation* item(See item 1 in section 2.3). One participants observed that some of the QWL factors might be connected as he stated that(17:34-18:09):

> *"Also in regards to the Work Life Balance[...] When [my wife] was in [company name] in the job she had. There Work Life Balance was not something...If you prioritized this highly, then you should not work there, because in certain periods they would work, work, work all the time. But they also made more money..."*

Here another participant immediately disagreed, as she had also worked in the mentioned company(18:10-18:17):

> *"I didn't at all.[Laughter] I received the worst salary."*

After discussing the QWL factors the conversation progressed towards the responses from the two week mESM study. The participants were presented with a total statistic of their responses, which can be seen in Figure 6.4 below.

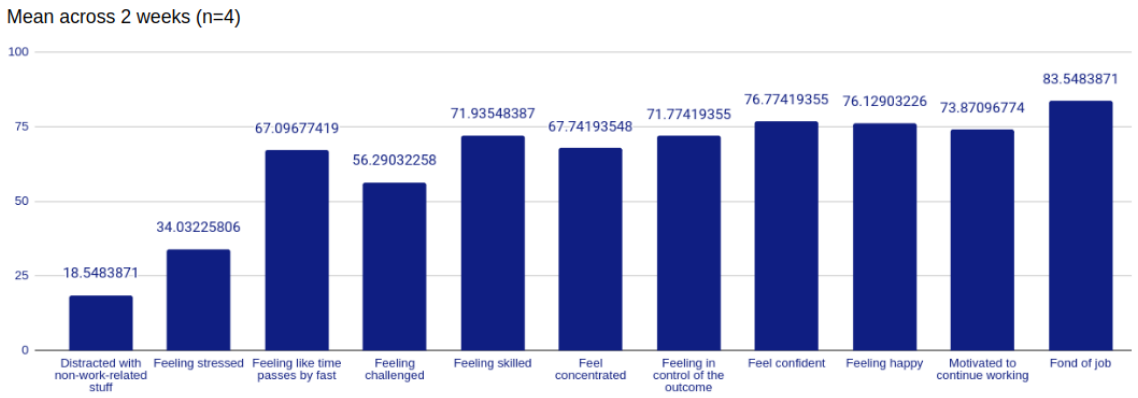

Figure 6.4: Bar chart showing the mean of the total responses recorded by the 4 participants of the mESM study. The X-labels have been rewritten for space saving purposes.

When presented with the high job satisfaction rate, one participant, who seemed to have understood, how to respond to the ESM signals, stated that(19:46-19:55):

> *"You know, regarding the job satisfaction, it was responded to based on which assignment you did at that time."*

He continued(20:14-20:32):

> *"I was thinking, that you missed some of my best tasks. And you hit, at one point, a very bad one. Then I thought, about how to respond to it, and I chose just to respond based on the task at hand."*

When the researcher commented on the low distraction rate("I'm currently preoccupied with circumstances outside of work"), which is the first item in the plot above, which was unexpected, due to all the work being done from home offices. One participant stated(22:18-22:50):

> *"It might be an indicator, that you have come across a time period, where we have been very busy. So there has not been a lot of time for not concentrating on work, as there has been plenty to take care of. I think that, if you had come across one of the more dead periods, then that one, would probably increase relatively much. Then you might have done the laundry, and then you might have done something else."*

When asked most of the participants stated, that they used around, or less than, a minute on each response, and that the time it took to respond decreased, as they became more familiar with the survey. 3 out of 4 participants agreed, that the mESM study was not an annoyance during the work day, however, one person disagreed stating(32:42-33:00):

> *"I think that I was under a lot of pressure during the first week. Then my stress level was fairly high. And I think that... Now you have all said that you didn't find it annoying or disturbing, but unfortunately I think it was."*

Later during the meeting, when asked about the item revolving around stress, it was suggested by the researcher that a possible rewording of the item could have been better, so the item was about time pressure rather than stress. As one participant stated(42:20-42:25):

> *"That was what I interpreted it as. Like if you were under great time pressure."*

The same participant also expressed confusion about some of the items(34:39-35:10):

> *"I do think,[...] that I mixed up some of the later questions[...]. I felt a bit like I responded to the same every time sometimes. Such as 'Feeling confident' and 'Feeling happy'. I think that I messed it up, and that in my head they were hard to separate."*

One participants stated that, during meetings, he would take a mental snap shot of the situation and react to the signal afterwards, where he would also provide the number of people, who had been in the same meeting. However, other participants would, after meetings, say that they were alone, since the meeting had now ended.

6.1.4 Suggested changes to the test

When asked about it would require, for participants to respond to on every signal one participants, requested a longer signal life time. Another suggested and end-of-day approach, which would make the test be more similar to the DRM mentioned in section 2.6.

Furthermore, a more convenient device was suggested, however, some of the participants had, at this point in time, already been made aware of the study revolving around a smart watch. Another suggestion were fixed signal times, so one would know, that at a certain time, one would have to react to a signal, and could also write it into a calendar. One participant agreed, and continued that fewer items, would also have made the person respond more often.

Moreover, it was suggested to make it more fun to respond, so one would feel as it was a small game every time. This participant suggested to make it more graphically pleasing and potentially use icons, and also make the items be different every time. Another participant, however, liked that the items became routine, as it did not require much consideration, and one was able to quickly respond, once the items had become familiar.

A price was also suggested, so that one was rewarded for high response rates, or if a chosen avatar could express happiness or sadness depending on the response rate. A reference to the Japanese toy *Tamagotchi* was made[2]. Furthermore, it was suggested that there could be a collective reward, if the measured team or department collectively had high response rates, which might make more people feel obligated to respond, as it would affect the whole group.

6.1.5 Flow questionnaire

In order to determine, whether or not flow had been present during the ESM test, as indicated by the ESM results in Appendix E, the participants were asked to fill out a Flow questionnaire. At this point in time, they had all been introduced to the state of *Flow*, through both the Focus Group meeting and through a header text in the questionnaire.

[2]Wikipedia page for Tamagotchi: https://en.wikipedia.org/wiki/Tamagotchi (visited on: 23-05-2021)

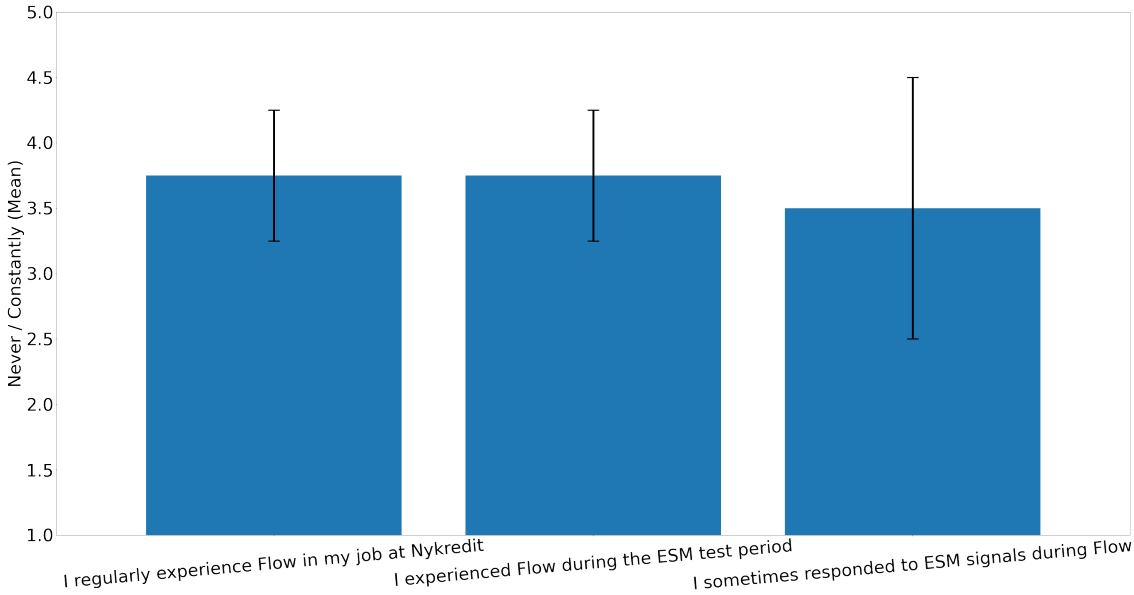

Figure 6.5: Bar chart showing the results from the Flow questionnaire, which all participants(n=4) responded to.

According to the respondents themselves, *Flow* is fairly common in their daily work, as Figure 6.5 shows. An optional comment text input was added to the questionnaire, which one participant filled in with a long paragraph. The following is the full translated comment(The original Danish comment can be seen in Appendix section F):

> *It very much depends on, which tasks you are working on, and which other factors come into play. It might happen that I'm working on some video for hours without noticing time passing, but it depends on, whether or not other colleagues are reaching out to me. In contrast, there are days, in which you get a lot of small tasks through your email, which makes you jump from one project to another, without having a chance to dive deeply into any of it. I think that a feeling of flow is more noticeable during larger projects, which you work on for a while - or if you are too busy for something else and you've booked in your calendar to not be disturbed. And it definitely also has something to do with your motivation towards the task - it is much easier to dive deep into projects you think are cool to work with - you get more easily distracted, if it is a bad/boring task :) The signals were mostly not responded to, when I was deeply involved with something, but rather afterwards. Not that there was anything stopping you - since it was the same things you was asked about every time, you could quickly get through the survey without really thinking to much about it, or really divert your focus from what you were doing. You also knew that you had an hour to respond, so it didn't have to be done here and now.*

6.2 Part 2: Wearable ESM design

As previously mentioned in subsection 3.2.3, it was, mainly due to COVID-19 restrictions difficult to get access to test participants, which is why only 2 people were included in the Usability test described below.

6.2.1 Usability test

A small first iteration Usability test was conducted in order to eliminate early issues with the application. The 2 participants were asked to think-a-loud while exploring the Wearable ESM application on the Samsung Galaxy Watch 3, after being introduced to the context, in which the application would be used. After each test the participants were asked to fill out a SUS questionnaire.

6.2.2 SUS results

A calculation of the SUS score was performed, which resulted in a SUS score of 88,75. According to UXPlanet this is considered an *Excellent* score[3]. Figure 6.6 below shows the individual responses from the 2 participants.

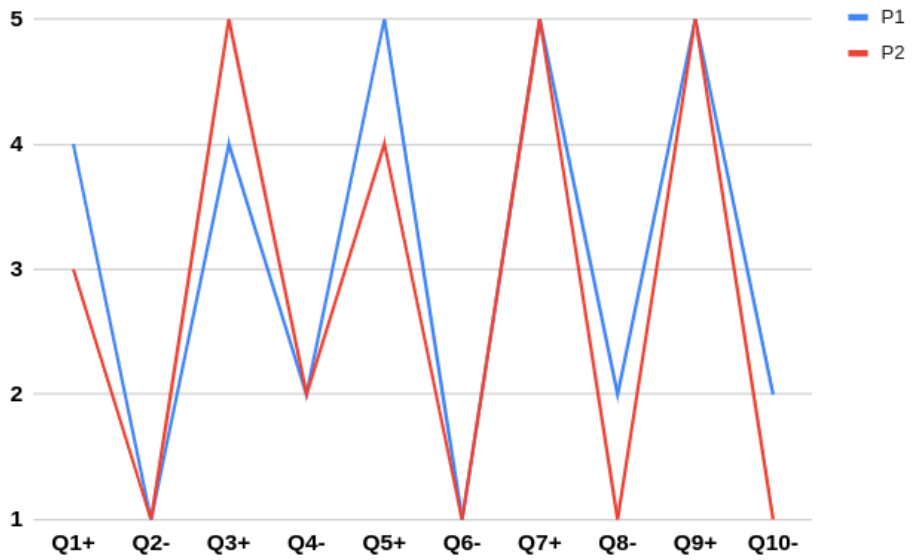

Figure 6.6: Line chart displaying the SUS responses from the 2 participants.

Every other item contained within the SUS questionnaire is worded positively and negatively, which is the reason for the zigzag pattern displayed in the line chart above. In order for an application to receive a top SUS score, ideally the responses would switch between 5 and 1 throughout all the items. This application was able to produce good results in the SUS questionnaire, however, only 2 people's responses were recorded, and the results might have been different if more had participated in

[3]UXPlanet SUS Calculation procedure and scoring table: https://uxplanet.org/how-to-measure-product-usability-with-the-system-usability-scale-sus-score-69f3875b858f (visited on: 22-05-2021)

the test. Especially if the demographic had been more broad, and included older, and potentially less technically skilled people. Both participants, a male and a female, included in this Usability test were employed in an office environment and belonged to the *Millennial* generation. As previously mentioned in subsection 3.2.3 one of the participants had experience in using smart watches, which also might be a reason for the high score. Furthermore, the participant without experience, was observed pressing the two physical buttons, which are used as *Back* and *Home* buttons, leaving the participant confused as the app would close. However, due to the application simplicity and repetitiveness, once the participant had started using it, this confusion was resolved.

6.2.3 Suggested changes to the application

A few points were raised by the participants, which were taken into consideration for future iterations. The round slider color, which changed from a red to a green color depending on the value input by the user, raised some confusion. One participant highlighted that there was a mismatch between a red color, and the displayed red *"Mildly"* label. Furthermore, it was suggested by both participants that the Red and Green, might be influencing users to respond more positively, and suggested that a more neutral color might be more beneficial. The colors were therefore changed to a blue color, which changes from a less saturated blue to a more saturated.

Another point was raised, by the participants, as they understood that the aim of the application was to measure employees in any work place. It was suggested that the application should be tailored to non-english speaking users, who might not understand the on-screen text. They exemplified by mentioning people of an older generation, such as their parents, who would not be able to understand the items in the application. There was no language changes made to the application after the test, however, the point is valid, and should be taken into consideration in future iterations. It was suggested that users should be able to choose a language on the application start screen, however, this would add another unnecessary step. An alternative addition, that could potentially be made to the application is a multilingual file for handling all strings, which would be dictated by the global settings on the smart watch it self, and thereby provide users with the opportunity to choose the preferred language through the watch settings.

6.3 Summary

In this chapter, the results from the two parts of this study has been presented. In the first part, the QWL questionnaire results show, how such a questionnaire can potentially be beneficial from a work place perspective, in determining, what QWL means for the workers, and thereby adjust processes accordingly. Furthermore, the mESM results were described, in order to test the data, which could potentially be produced, through the same type of test conducted using a Smart Watch. The focus group meeting was used to clarify some of the questions, which had surfaced during

data analysis. The focus group meeting includes a few Gamification related suggested changes from participants. The Flow questionnaire was put in place in order to confirm if the potential flow occurrences found, were potentially accurate. In the second part of the chapter, the results from the initial Usability test, were presented, which also includes some suggested changes to the Wearable ESM application.

7
Discussion

In this chapter, the finding of this study will be discussed, and the methodology used throughout this project will be described, along with the limitations of these. The chapter is, as previous chapters, divided into the two main parts of the study. This project might be difficult to replicate, as it, as previously mentioned, was conducted during the COVID-19 pandemic, where world conditions were not resembling normality, and work life of the test subjects was irregular. The participants, used in the study, were not tested during ordinary conditions, as they were all experiencing a work life from their home offices, due to the COVID-19 restrictions in Denmark. As this project reached a deadline, the country was slowly reopening, as restrictions were being lifted, which means that the conditions, and therefore, possibly the results, might be different, when, and if, the world returns to a more normal state.

7.1 mESM study

The mESM test was conducted with employees in a small digital team in Nykredit, one of the larger danish banks. According to job satisfaction measurements, Nykredit already show high levels of job satisfaction amongst their employees. The specific data of employee satisfaction results, was read by the researcher in the Nykredit Intranet, however, could not be included here, as it is not public record, however, a description of the results can be found on the Nykredit website[1]. The results from the current study also confirm a high satisfaction with the job. Therefore, there might not be an urgent need for the company to improve, as it seems that Nykredit already provides great conditions for their employees. This does not mean that employees regularly experience flow, and more studies, similar to the current, should be conducted, if flow was to be a focal point in Nykredit. This study should, therefore, also expand to other companies, where there might be a greater need for it, however, this was not possible within the scope of this project.

One participant seemed to have misunderstood the boundaries of the scale, and maxed out on several occasions. This was interpreted as a sign of the scale being unclear and/or insufficiently explained. A rating of 10 on the scale, should generally be a rare occurrence. Therefore, it is an indication of the scale not being properly explained both during the pre-test meeting and within the scale header itself. This was not further explored during post-test focus group meeting in order to prevent

[1]Webpage describing employee satisfaction in Nykredit(Only available in Danish): https://www.nykredit.com/samfundsansvar/ansvarlig-forretningspraksis2/medarbejderforhold/ (visited on: 02-05-2021)

the participant in question to be singled out, and thereby compromising his/her anonymity. In general the scale needs further testing. Even though no participants commented on a 0-10 point scale, it might be beneficial to test other formats, such as a 5-point scale. It might be hard to choose between such a fine tuned scaled, when it comes to assessing one's own mental states. However, the data might also become less accurate, and more difficult to analyse and draw conclusions from.

The points in time, in which flow was potentially experienced, according to the results from the mESM study, the participants also reported high stress levels, which is detrimental for the flow experience(Csikszentmihalyi, 1997, p. 106). However, subjective stress level tolerance might also be different from person to person, and there might be differences in personal thresholds for how stress is experienced. Accompanied by these high stress levels, were also high happiness and job satisfaction levels. Therefore, a confirmation of participants self-reported stress levels, using sensors in the Smart Watch, could potentially be very useful. Furthermore, the stress item in the ESM study, might need to be reworded, or properly explained, as it can be perceived as a question about short term time pressure.

An anonymous approach, of conducting ESM studies, is a limitation, as it makes it difficult to ask participants directly about specific situations. Where data might suggest the presence of flow, querying about specific situations, would also compromise the anonymity. Furthermore, provided that the anonymity would not be an issue, there might be some benefit in being able to identify specific activities, as this might make it easier for participants to recall, what they were doing, when asked about it afterwards. And if the data would then show a flow activity, where non was experienced, it would be easier to identify, and thereby adjust the test.

When asked about suggestions for the ESM test, it was not a coincidence, that the participants would respond in *gamification* terms. These particular participants are used to thinking in terms of gamification, as they are working with E-learning in their daily work, and are therefore used to consider, how to improve E-learning modules, in order to make these more motivating and engaging for the users.

It is worth noting that the Flow questionnaire, was added at a late stage of the study, as it, through the data analysis, became increasingly evident, that this crucial question had not been answered. The question about flow, could potentially have been more accurate, if asked immediately after the mESM study had been concluded, or possibly by including it in the discussion during the post-test focus group meeting. Instead it was asked on May 25th 2021, more than 1 month after the last ESM signal, which was on April 23rd 2021, leaving it potentially subjective to recall biases. Furthermore, due to the familiarity biases, it might also have produced more positive results, than it would have otherwise.

7.2 Wearable ESM application

There is a need for several iterations in order to develop a Wearable ESM application, which scores highly on the SUS scale. Due to the low sample size of the Usability test, there might still be usability issues, which have been overlooked, and the current SUS score of the application is not reliable. Therefore, it would be beneficial to do more testing in regards to Usability.

Even though consumer Smart Watches, such as the Samsung Galaxy Watch 3, used throughout this project, contain sensors for measuring heart rate, stress level, blood oxygen etc. it should be noted, that the accuracy of these sensors, might not be as accurate as medical grade equipment. This is also disclaimed on the watch itself, through text warnings in various fitness applications. It is stated that the measurements, should only be interpreted as estimates for fitness purposes, and not for medical diagnosis. Furthermore, if such devices were to be utilized for measuring employees heart rate and state of mind, researchers need to ensure that they stay compliant with the general data protection regulations(GDPR), and collect the necessary consent before conducting such studies. The HRV analysis method used in this study(SDRR), was primarily used to exemplify, how to potentially handle raw RR-interval data, which can be obtained by the smart watch censors, and is not reliable. In order to obtain more accurate measures of stress, alternative methods need to be researched and implemented.

In order to receive accurate data, from the self-reported ESM study items, careful considerations, should be put into translating these, as it was suggested by the Usability test participants in subsection 6.2.3, and the text strings should produce the same response regardless of the chosen language.

7.3 Summary

The framework developed throughout this study, should not be considered a replacement, for traditional employee satisfaction surveys, but rather a supplement, to gain insights into employee satisfaction on a day-to-day basis. The QWL factors questionnaire, could potentially be useful in dictating a direction for future improvements, within a work place, while an ESM study, can help measuring the effects of this. There is no absolute truth to draw from this study, due to the complex nature of human behavior, state of mind, psychological and physiological differences in individuals, and vast variety of workplaces etc. However, it might serve as an inspirational study, which can potentially spark further research within the field, and possibly in various specific job areas in society.

8

Conclusion and future works

The aim of this study was to, in broad terms, assist in increasing the happiness of workers, and to suggest a framework for measuring the Quality of Work life(QWL) in any given work place through Wearable Experience Sampling.

By examining what makes employees happy and motivated at work, and by focusing on what employees expect from their work place, it might be possible to pin point, which concrete initiatives to put in place, in order to improve certain aspects of the work environment, and thereby increasing QWL, and ultimately productivity. Since Generation Y, is increasingly entering into the work force, soon to be followed by Generation Z, one such initiative could potentially be Gamification, as the main goal of gamification is to elicit motivation towards particular activities, and evoke flow states, which is described as being the optimal human experience.

Moreover, it was explored how the effect of such initiatives could potentially be measured, through Wearable Experience Sampling, and a Smart Watch application prototype, was developed to this end. The data, which such a device can provide, was tested, through a remotely conducted experience sampling study, during a 2 week period, with employees at a digital team in Nykredit(n=4), in order to determine the possibility of detecting flow states. Indications of flow was found through data analysis, and the presence of flow was confirmed by the participants, however, more testing needs to be conducted in order to conclusively regard this method as being sufficiently accurate.

8.1 Future works

The present study is left open-ended, and could potentially serve as inspiration for future works in this field.

8.1.1 Wearable Experience Sampling Method

Due to the scope of this project and irregularities, caused by uncontrollable pandemic related circumstances, the Wearable Experience Sampling Method(ESM), was never tested in a natural setting. Therefore, the Smart Watch application developed currently only serves as a proof of concept prototype, and further design iterations should be considered. Furthermore, an ESM test, similar to the one conducted in this project, should be conducted, in order to properly test it's applicability in a real world environment.

8.1.2 Tizen OS

Tizen Studio, which was the IDE used to develop the application, was not an ideal development platform, and was experienced as slow and somewhat broken at times. For example, it was not possible to debug the developed web-application, through a newer version of Google Chrome's developer tool, and therefore, in order to accomplish this, Google Chrome had to be downgraded to an older version. This might be an indicator of the ongoing online speculations, regarding Samsung making a switch towards WearOS, which is a C/C++ and Java based operating system created by Google[1]. This has still not been confirmed, however, in the future, an application, such as the one developed in this study, might have to be programmed for a different operating system.

8.1.3 Personal ESM tracking

There might be potential in making ESM tracking personal, so Smart Watch Users are able to follow along with their own progress, and track their own flow occurrences, and motivation. Similar to the applications, which exists on these types of watches today. Applications such as, exercise trackers, self-reported water and calories consumption, stress and pulse measurements, sleep trackers etc., which are currently part of the Samsung Galaxy Watch 3, are all used in order to measure physical health. However, applications for tracking mental health, or Quality of Life, do not seem to be available.

8.1.4 Measuring stress through heart rate variability

In order to, more accurately, measure stress levels on users of the application, more research has to be conducted. Effective methods for artifact correction of the available RR-interval data, needs to be further explored, followed by more research into, which HRV analysis methods most accurately provides reliable data on ultra-short-term (<5 min) measurements. Furthermore, it might be advantageous to explore, how machine learning could potentially be used in order to handle, organize, and classify these short RR-interval readings into meaningful measurements.

8.1.5 Novo Nordisk

The findings from this report will potentially serve as inspiration for a similar project, currently being conducted in Novo Nordisk, and further testing and discoveries will therefore potentially be made within this topic.

[1] https://www.theverge.com/2021/5/18/22440483/samsung-smartwatch-google-wearos-tizen-watch (visited on 23-05-2021)

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Appendices

A QWL factors coded in relation to SDT

Table .1: Table showing how the QWL factors relate to types of motivation and the psychological needs.

	QWL factors	SDT factors	SDT 2.0 factors	SDT needs
1	Adequate and fair Compensation (A&FC)	Extrinsic	Controlled	
2	Opportunities for Growth (OG)	Intrinsic	Autonomous	Competence
3	Safe & Healthy Working Condition (S&HW)	Extrinsic	Controlled	
4	Social integration & Cohesiveness (SI&C)	Intrinsic	Autonomous	Relatedness
5	Work & Total Life space (W&TL)	Extrinsic/ Intrinsic	Controlled/ Autonomous	Autonomy
6	Supervisor (Su)	Extrinsic	Controlled/ Autonomous	Autonomy
7	Human Progress Capacities (HPC)	Intrinsic	Autonomous	Competence
8	Constitutionalism, Justice and Equity (CJE)	Extrinsic	Controlled	
9	Rewards and Recognition (R&R)	Extrinsic	Autonomous	Competence
10	Job Security (JSe)	Extrinsic	Controlled	
11	Autonomy & control at work (A&C)	Intrinsic	Autonomous	Autonomy
12	Participation in decision-making (PDM)	Intrinsic	Autonomous	Autonomy
13	Communication (Co)	Intrinsic	Autonomous	Relatedness

B QWL Survey social media text

"Help with master thesis.
If you have work experience, I would like to ask for your help. I'm currently doing my masters thesis on Quality of Work Life.
I've created a survey related to factors, that play a part in our quality of work life, and how we prioritize these factors.
So if you have about 10-15 minutes I would be glad, if you could help me out.
*You can find it here: *SURVEY URL**
Thank you very much."

C ESM Signal message : Danish translation

This message was sent through a Microsoft Teams chat message to all participants at the same time.

ESM SIGNAL!

Besvar formularen ud fra den pågældende aktivitet, du foretog dig på signaltidspunktet:
SURVEY URL

Husk at bruge dit unikt generede deltager ID.
Signalets levetid: 1 time fra signaltidspunktet.
N.B.: Hvis ikke du når at reagere på signalet inden for levetiden, skal du blot ignorere det, og afvente kommende signaler.

D QWL plots

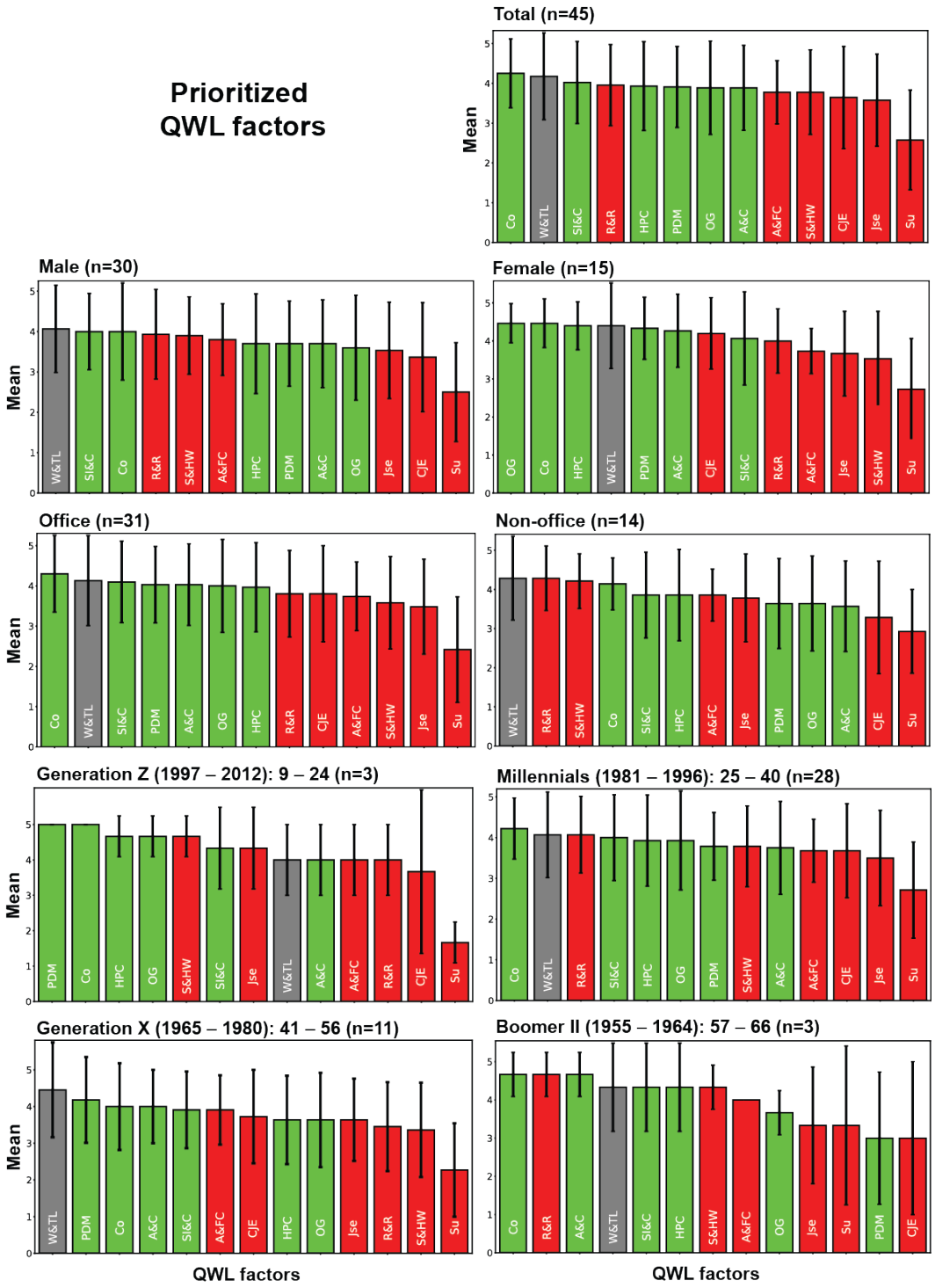

Figure .1: Figure showing the results from the QWL survey divided into subplots with demographically grouped responses. Green bars signify intrinsically motivated factors, whereas Red bars signify extrinsic. The grey bar signifies both. Standard deviation is indicated in black on each bar.

E ESM Results

Participant ID: U555BLUECROCODILE

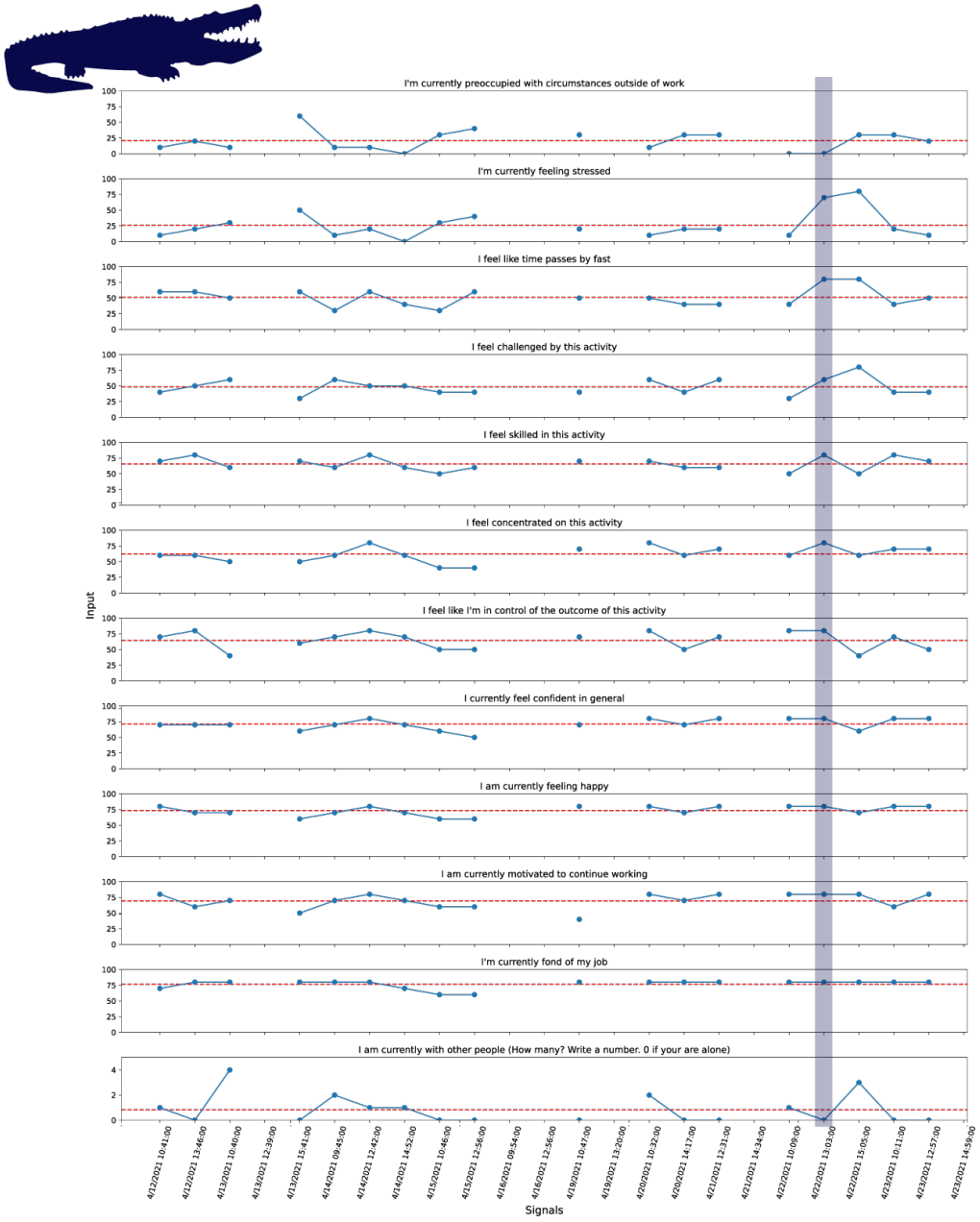

Figure .2: Graph showing the responses from the 2 week ESM study by participant with ID: U555BLUECROCODILE. The red dashed line indicates the overall mean, for each item, across the 2-week period. Participant's response rate: 75% of 24 signals. The transparent vertical bars signify potential flow experience.

Participant ID: T5GREENLION

Figure .3: Graph showing the responses from the 2 week ESM study by participant with ID: T5GREENLION. The red dashed line indicates the overall mean, for each item, across the 2-week period. Participant's response rate: 62,5% of 24 signals. The transparent vertical bars signify potential flow experience.

Participant ID: H669PINKBIRD

Figure .4: Graph showing the responses from the 2 week ESM study by participant with ID: H669PINKBIRD. The red dashed line indicates the overall mean, for each item, across the 2-week period. Participant's response rate: 54,16% of 24 signals. The transparent vertical bars signify potential flow experience.

Participant ID: E599REDHORSE

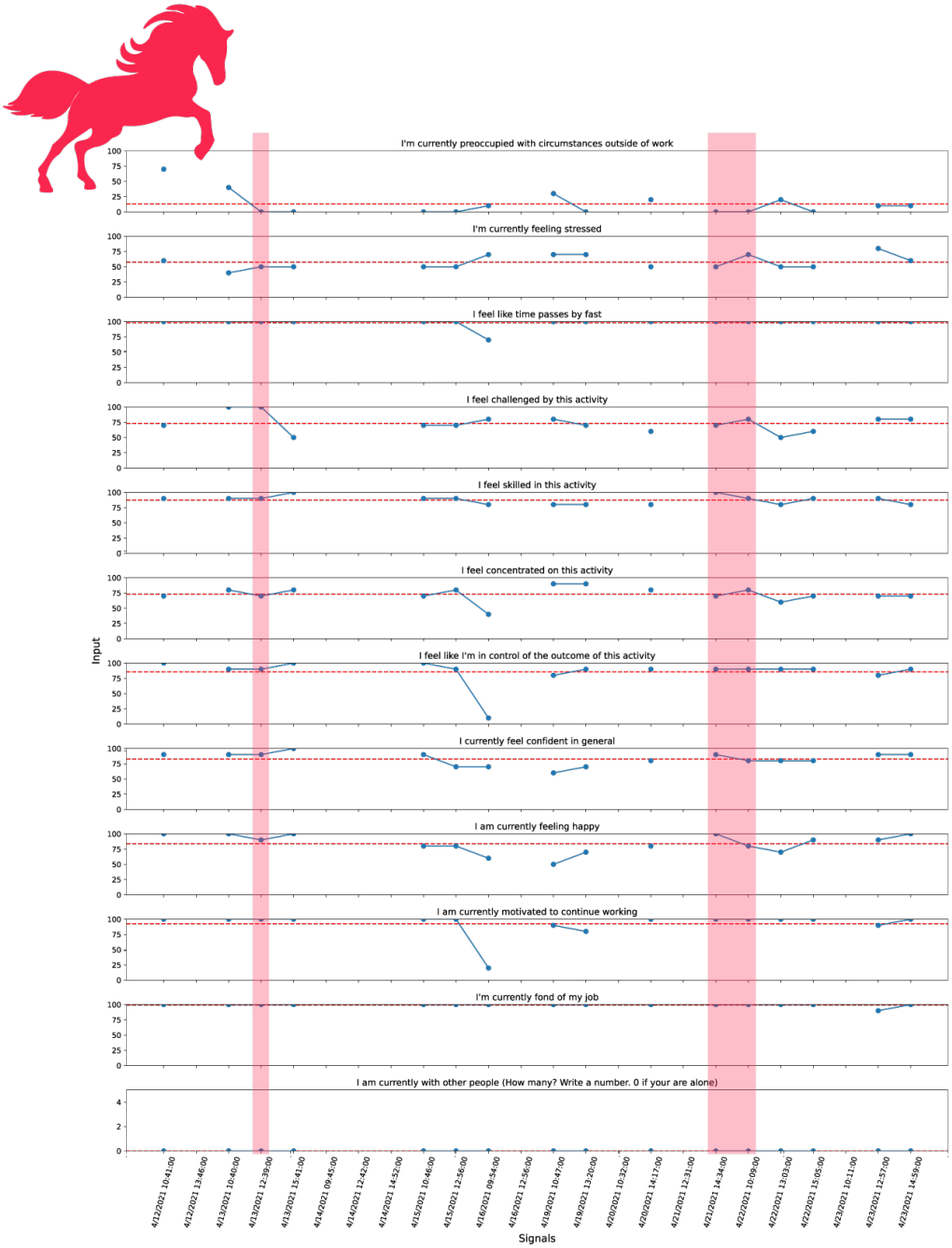

Figure .5: Graph showing the responses from the 2 week ESM study by participant with ID: E599REDHORSE. The red dashed line indicates the overall mean, for each item, across the 2-week period. Participant's response rate: 66,66% of 24 signals. The transparent vertical bars signify potential flow experience.

F Flow questionnaire comment(Danish)

The full original danish comment left by one of the participants.

> *Det kommer meget an på, hvilke arbejdsopgaver man sidder med, og hvilke andre faktorer, der spiller ind. Det kan sagtens ske at jeg sidder, eksempelvis med noget video i timevis uden rigtig at mærke tiden gå - men det kræver lidt at der ikke er nogen kollegaer eller andre, som skal have fat i mig. Der er modsætningsvis andre dage, hvor der kommer en masse små-ting ind på mail, som gør at man hele tiden skal hoppe fra projekt til projekt, uden rigtigt at ende med at fordybe sig i noget. En følelse af flow synes jeg umiddelbart er mest mærkbart i større projekter man arbejder med over længere tid - eller hvis man har for travlt til at tage sig af noget andet og har booket kalenderen til ikke at blive forstyrret. Og det har helt sikkert også noget at gøre med ens motivation for opgaven - det er væsentligt lettere at fordybe sig i projekter man synes er fede at arbejde med - man bliver noget nemmere distraheret, hvis det er lidt en øv opgave :) Signalerne blev for det meste ikke besvaret når man var virkelig dybt i noget, men på bagkant i stedet. Ikke at der nødvendigvis var noget til hinder for det - eftersom det var det samme man blev spurgt om, hver gang kunne man pløje sig igennem spørgeskemaet uden reelt at tænke meget over det eller flytte fokus reelt væk fra hvad man ellers sad med. Men man vidste også at man havde en time til at svare, så det ikke nødvendigvis behøvede være lige nu og her.*