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Get your head together: designing an adaptive digital intervention that improves the emotion regulation of students

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Abstract

Stress among students has become a hot topic in the news lately (Pieters, 2018). Counselors and therapists that work for universities have seen quite an increase in students visiting them. Many students suffer from stress, anxiety, depression and burn-outs. The amount of students experiencing these issues has increased so much, that even universities have noticed this and are starting Mental Health awareness weeks or mindfulness workshops. Utrecht University (UU) is one of these universities. The UU has recently hired an extra counselor for students and PhD'ers, because waiting times were increasing fast. Waiting time for a person to get therapy in the Netherlands has now increased to approximately 2 months. It can already be quite a challenge to admit to oneself you need help, however, waiting another two months after taking this big step, might discourage many people to actually seek help. Perhaps technology might be able to already provide some help and support in these two months, or in general at all. Previous researches have shown that digital applications can help people monitor and improve their behaviour, for example in fitness and for people suffering from chronic disease. The goal of this thesis was to design a digital intervention (in the form of an algorithm) that helps and improves student's ability regulate their emotions. This digital intervention uses a well-researched and popular emotion regulation technique: mindfulness. Seven different studies were done, in which the stressors students experience were collected, an expert and students gave their opinion on what mindfulness exercises one should advise based on stressor and personality, and finally the algorithm was designed. In this research, the algorithm is not tested for it's effectiveness. However, the perceived effectiveness was tested among students and showed some interesting results. Some exercises were perceived as effective, while others were not. There were a few different explanations possible, as to why some exercises were perceived as effective, and some were not. However, more research is needed on the effectiveness of this algorithm, before it can be implemented.

Contents

List of Figures

List of Tables

1 Introduction

It has become quite a hot topic in the news lately: students that struggle with stress and mental health issues (Pieters, 2018). Therapists and other mental health professionals have claimed they have seen a substantial increase of students in their client base over the last few years (Wakeford, 2017). Often the mental health issues students deal with are related to stress, time-management, financial issues, language barriers, homesickness, and loneliness (Mori, 2000; Hunt & Eisenberg, 2010; Levecque, Anseel & De Beuckelaer, 2017).

Of course, one can find some support for mental health problems by contacting a therapist. The average waiting time for a therapist in The Netherlands is currently between six to eight weeks (GGZ Nederland, 2018). That means students who really feel they need help, will have to wait and live with their mental health problems for another two months. The decision to seek help with a therapist is already quite a big step for many people, but also having to wait another six to eight weeks might shy them away from even trying.

Technology might provide a possible solution to this problem. An adaptive e-coach that could support these students in this new phase in their life, might help lessen the problems these students encounter. Exercises provided by the e-coach could help students deal with stress. Of course, such an e-coach can not replace human contact through a therapist (yet), but it could provide some extra support and maybe even bridge the eight-week waiting time towards a therapist.

E-coaches have been proven to succeed in the past in different (medical) areas. In fitness, it is has become quite normal to use an e-coach to motivate people to work out. The coach is often presented in the form of an app that reminds and motivates people to move. These apps have proven to motivate people to work out and stick to their diet (Simons et al., 2013). Another (medical) area e-coaches are being used in are for people suffering from chronic diseases. For example, Wayne and Ritvo (2014) researched the effectiveness of a digital intervention for poorly managed diabetic patients. They developed an app that coached these patients to measure their glucose and mental state every day. This app contributed to patients better managing their disease, but also doctors gaining a better overview and understanding of their patients, since they were allowed to see the data in the app.

Other research on digital coaching, that is more similar to our topic, is the research done by Wade (2010), who has performed a large systematic literature review of how the internet might assist patients that suffer from depression and anxiety. This review provides a well-defined overview of four different areas in which the internet might help these people:

1. Information provision

2. Screening/self-diagnosis

3. Therapy

4. Compliance support (compliance in this case meaning the extent to which a patient follows the advice of a therapist)

In this case we are mostly interested in the therapy part, since we aim to design an e-coach that supports the student, and possibly the therapy part. Wade (2010) showcases in his article that there are roughly two types of 'e-therapy' offered on the internet: either

remote therapy from a therapist using the internet as a medium, or interactive tutorials without a therapist being present. Both types have their advantages and disadvantages. For example, the interactive tutorials can be done by anyone at any time, while the remote therapy needs to be scheduled and might include waiting time. However, in remote therapy the dropout rates are much lower in comparison to the interactive tutorials (Wade, 2010).

What if we were to add a third possibility: an adaptive e-coach making use of artificial intelligence? Just like a human, the coach would adapt to the person that is using it. There are many factors which can be used for this adaptation, such a user's personality, affective state, mental health issue, stress indication and so on. An example of such an adaptive coaching app, is the SleepCare app by (Beun et al., 2016) that coaches people who suffer from insomnia in an adaptive manner. It provides relaxation assignments and scheduling help to help people manage their insomnia issues. In preliminary tests the SleepCare app showed some promising results (Beun et al., 2016).

However, to be able to design such an adaptive digital e-coach which selects appropriate exercises, we need to know what stressors and student's personalities require what types of exercises. That is why we ask the following research question:

What effective adaptive digital behavior intervention can we design, for supporting students to improve their ability to regulate emotions?

Behavior intervention in this case stands for the e-coach that will be designed, in the form of an algorithm.

To answer the main research question, the following sub questions will be answered:

1. What stressors do students experience and how can these be portrayed?

2. What emotion regulation techniques exist?

3. What are already existing digital interventions for emotion regulation?

4. How do people adapt the selection of emotion regulation techniques to the characteristics of the person and the stressors experienced?

5. What algorithm can mimick these adaptations?

6. What is the perceived effectiveness of the resulting behavior intervention?

The remainder of this thesis is structured as follows. Section 2 will elaborate on different concepts and theories surrounding stress, digital interventions, adaptive algorithms and recommender systems. Section 3 contains the main research method and the different studies that were done within this method to answer the research questions. Section 4 contains the final algorithm that has been designed based on the multiple studies that were done in section 3. Section 5 concludes the research and answers the sub research questions and main research question. Section 6 contains a discussion about the research, it's result and possibilities for future research.

2 Literature review

2.1 Stress

This section will present the related work on stress, the impact of stress, stressors and stress among students. It contains definitions of the concepts of stress and stressors, how to categorize stressors, the research that has already been done on stress and students, and what stressors they specifically experience.

2.1.1 Stress defined

Stress is a concept that is hard to define exactly. Everybody experiences stress in a different way or would describe it differently. However, there are some similarities to the experience of stress, despite the situation in which the stress occurs. Using these similarities, many researchers and philosophers have tried to define stress. It is one of the most researched topics in the history of science. This is not surprising though, since it is something we all experience, either in a positive or negative way.

The term stress has existed for quite some time. However, the term was mostly used in its physical sense. For example, in engineering stress was the force that was acting against a resistance (Selye, 1956). An example of such a force would be the changes that happen to an elastic band when it is stretched. Selye (1956) was the first researcher to use the term stress as a concept that describes the psychological stress we all experience from time to time. This caused other countries, that did not have a specific word for stress in their language, to adopt this English word in their own language to indicate the experience of psychological stress. Even though Selye did popularize the term stress and the way it is used today, he did not exactly define the concept of stress in a concise manner. In his book 'The Stress of Life' he wrote eleven statements that describe what stress is not. However, he does not exactly define in his book what this psychological stress is. It is still quite vague. Because of this, we look at other definitions of psychological stress. A very prominent and often-used definition of stress is the definition by Folkman et al. (1986). Lazarus and Folkman are amongst the biggest pioneers in stress- and emotion-related research. They define stress as:

> "Psychological stress is a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being. (Folkman et al., 1986)"

This definition is based on two processes: *cognitive appraisal* and *coping*. These two processes function as critical mediators of stressful situations and their, immediate or long-term, outcomes (Folkman et al., 1986).

A person evaluates the relevance to his or her well-being of a transaction between him or her and the environment. This evaluation is what Lazarus defines as *cognitive appraisal* in his theory of stress (Lazarus, 1995). If the transaction is evaluated by the person as a threat, harm or challenge to the person's well-being, it can be defined as stressful. *Harm* refers to damage that has been done, such as failing an exam. *Threat* refers to harm that has not yet happened but is anticipated soon. For example, a relative suffering from a chronic disease whom might pass away any moment. *Challenge* is overcoming obstacles and experiencing growth as an individual. It is more focused on a possible positive outcome, in comparison to harm and threat. However, it can still have a negative outcome as well.

According to Lazarus, there are two types of cognitive appraisal: *primary appraisal* and *secondary appraisal* (Lazarus, 1995). In primary appraisal a person evaluates whether he or she has something at stake in a situation. For example, is there possible harm or benefit involved? Is their own health or the health of another person at risk? In secondary appraisal a person evaluates whether anything can be done to prevent harm from happening, or to overcome harm that has been done. In secondary appraisal the process of *coping* will begin.

Folkman et al. (1986) define coping as: "the person's constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the person's resources." Coping is a process which is never considered good or bad. It is simply a person's efforts to manage the demands that come during a stressful situation in a specific context. It does not matter whether these efforts are successful or not. Coping has two main functions: changing the situation that is causing the stress (*problem-focused coping*) and regulating the stressful emotions that come with it (*emotion-focused coping*) (Folkman et al., 1986). These two functions almost always appear together when coping with a stressful situation.

Finally, one must also consider the *outcome* of a stressful situation. The outcome of a stressful encounter refers to an individual's judgement of how successful the encounter was resolved (Folkman et al., 1986). This judgement is based on the context of the encounter and a person's values, goals and expectations. The most favorable outcome is of course for the problem that was causing stress to be resolved and the outcome is in alignment with a person's values, goals and expectations. However, a person can also feel negative about an outcome, because it is does not adhere to a person's expectations, even if the problem is solved. The other way around is also possible: a person is happy with an outcome, even if the problem is not resolved entirely, but he or she tried their best.

As seen in the definition by Folkman et al. (1986), stress is quite a complex concept to define. It entails different processes, such as cognitive appraisal, coping and the outcome. The definition of Folkman et al. (1986) is very much focused on a person's judgement of the environment and situation they encounter. Many other researchers have adapted to this view when formulating their own definitions of what stress is (Aldwin et al., 1994; Taylor, 2003).

However, even though this is a definition of stress that is widely used, it is not clear of imperfections. As Hobfoll (2004) mentions in his book on the psychology and philosophy of stress, this definition of stress is very much focused on our western individualistic culture which perceives stress as something that is appraised strictly personal. Yes, everyone copes with stress in their own way, but there is a commonality in the appraisal of stressful events within different groups. For example, in a group of researchers there can be common stressful situations such as the deadline for a paper or leading an experiment in a smooth manner. All researchers would appraise these situations as possibly stressful. In the same way, students can also have common situations they appraise as stressful, that other 'groups' of people do not have. These stressful situations are 'activated' due to certain *stressors*. In the next chapter we will define what stressors are and what types of stressors exist. In this research we will be using a combination of the definitions by Folkman et al. (1986) and Hobfoll (2004). We use the way Folkman et al. (1986) define the process of stress through appraisal and coping but will acknowledge that there is commonality within groups in what situations are appraised as stressful.

2.1.2 The impact of stress

Apart from defining stress, an abundance of research towards has been performed on the effects of stress on people, either physical or mental. In research on the physical effects of stress, there has been research on the effect of stress on the adolescent brain (Bremner, 1999; Romeo and McEwen, 2006; Lupien et al., 2007, 2009), the heart (Trichopoulos et al., 1983; Fuller, 1992; Kivimäki et al., 2006; Kivimäki and Steptoe, 2018), reproduction (McGrady, 1984; Fenster et al., 1997), weight (Roberts et al., 2007), sleep (Sadeh et al., 2004; Åkerstedt, 2006) and so on. Most of these researches showcase how stress has a bad influence on the specific part they are researching. For example, Lupien et al. (2007) showed in their literature review that stress influences the cognitive performance of young adults and adolescents. The part of the brain that takes care of memory performs worse if exposed to psychological stress. Another example is the research by Kivimäki et al. (2006) which showed the effect of work stress on coronary heart disease. Humans who experience long-term work stress had a 50% higher chance of developing coronary heart disease.

Apart from physical strain, there may also be mental problems that are caused by stress. Multiple researches show stress to be of significant influence on the development of a mental illness, such as burnouts (Ramirez et al., 1996; Lloyd et al., 2002), depression (Hammen, 2005; Kendler et al., 1998), anxiety disorder (Chaby et al., 2015) and more. All these researches found a connection between (long-term) stress and the development of a mental illness.

Because stress can have such a major impact on people's lives and health it is important to find ways to minimize the amount of stress and to help people cope with stressful situations. We have now defined what stress is and how it can influence people's lives. To understand how we can help people, and more specifically students, cope with stress we first must understand what stressors can cause stressful situations.

2.1.3 Stressors

Apart from the popularization of the term stress to indicate psychological stress, Selye (1956) also invented the concept of a stressor. Selye defines this concept quite simply:

> "A stressor is naturally that which produces stress (Selye, 1956)"

Thus, a stressor is something that activates the process and feeling of stress. Selye (1956) describes quite some stressors that are specific to an occupation, the climate and environment, and social and cultural stressors. For example, air traffic controllers experience quite some stress during their jobs (Selye, 1956). Even though they sit in a nice air conditioned room with their colleagues, they must focus continuously on their tasks, since they are responsible for the lives of many passengers. Hypertension and heart accidents are quite common among air traffic controllers (Selye, 1956). Thus, in this example, the task and responsibility that comes with their occupation are the stressors that cause these people to experience stress. An example of stressors that are related to an environment, is pollution or noise that can cause stress for people (Selye, 1956). In social and cultural stressors, one could imagine crowds, isolation and cross-cultural issues as stressors (Selye, 1956). There are many more examples of stressors that exist. However, Selye (1956) categorizes these stressors under different topics, such as occupation or the climate. These topics all describe specific situations (or occupations) in which different kinds of stressors exist. There can be countless situations in which stressors occur. However, these categories are quite specific and only focused on a certain topic (such as occupation).

Perhaps a better way to categorize stressors is to categorize them into certain demands. This is a more general way of categorizing stressors, in which all types of stressors can be included. As Selye (1956) mentioned in his book, air traffic controllers must do certain tasks and have responsibilities that might become stressors at some point. These tasks and responsibilities can be translated to certain demands. Kindness (2014) researched how a virtual agent can alleviate stress for community first aid responders. In his research he used the NASA-TLX to base a survey on, that measures what kind of demands and stressors community first aid responders experience. The NASA-TLX is a survey that measures task workload and the perception of these task demands (Kindness, 2014). The NASA-TLX is a highly validated and simple scale. Originally the NASA-TLX measures six workload components: physical demand, temporal demand, mental demand, effort, frustration and performance. Kindness (2014) has changed the six workload components, to better fit his research on stress in community first aid responders. First, he removed effort and performance, because it was not important to his research whether community first aid responders perform well or use the right amount of effort. He wants to know what stresses them out and how he can support them. Second, he added isolation and loneliness, and interruption. He decided to add these stressors, because they were often discussed during exploratory focus groups. Finally, he also added a fourth demand due to discussions in the exploratory focus groups: emotional demand. Many community first aid responders noted they sometimes felt the demand to show a certain emotion in a certain situation, for example showing sympathy towards a victim.

In short, the stressor categories are:

1. *Physical demand:* any physical activity that is demanded of a person. This can become a stressor if, for example, one must bike to work but is very slippery outside due to sudden snowfall.

2. *Mental demand:* any kind of mental activity that demands a lot of thinking. This can become a stressor if, for example, a student is partaking in a difficult test for which he or she must think very hard about the questions.

3. *Temporal demand:* any kind of time-related demand. An example of a stressor related to this demand could be time pressure.

4. *Emotional demand:* any kind of emotion that is demanded in a certain situation. For example, if a student is partaking in a social activity with friends, it is demanded (or expected) of him or her to be happy and excited.

5. *Frustration:* the feeling of frustration or annoyance that happens due to an activity. For example, planning to visit a specific restaurant, which turns out to be closed.

6. *Isolation/Loneliness:* the feeling of being alone and isolated from other people. For example, one can visit a party, but still feel alone among all those people, because you do not know anyone.

7. *Interruption:* when interruption is causing stress during an activity. For example, while concentrating hard on an exam, someone's phone rings which interrupts your concentration.

These categories have proved to be recognizable for people and were validated by Kindness (2014) and Smith (2016). We will also use these categories in this research to categorize stressors.

2.1.4 Stress among students

Researches about stress and stressors are mostly focused on the working population of our society. Since stress can have a major influence on peoples' lives and health, it is considered important to minimize stress at work, so the employer does not lose its employees or it effects the income of a company (Robotham and Julian, 2006). However, talking about stress and mental health issues has become less of a taboo in our society. Because of this, more people are speaking up about their struggles with stress and mental health issues.

University and college students have now become a topic of interest for researchers who are researching stress. It has become more apparent in the news and media that students are, very much so, struggling with stress and mental health issues (Brown, 2018; Hall, 2018; Henriques, 2014). University-linked therapists are busier than ever, while also other therapists note they have been treating more students for the past couple of years (Spitzer-Wong, 2018; Reilly, 2018).

Students experience some different stressors in comparison to the working population. Becoming a student requires many changes and new responsibilities in one's life. For the first time a student will start living on their own and will have new responsibilities such as doing the laundry and cooking. Ross et al. (1999) did a big survey among students to see what stressors students experienced most. They based their survey on the Student Stress Scale (Insel and Roth, 1985), the Taylor Manifest Anxiety Scale (Taylor, 1953) and other sources. A total of 40 stressors were defined. The following stressors were most frequent: change in sleeping habits, vacations/breaks, change in eating habits, new responsibilities, increased class workload, financial difficulties, and change in social activities. Ross et al. (1999) note in their research that this survey was done during the spring, in which many students were planning for spring break, hence why vacation/breaks proved to be a stressor in this case. This research showcases most stressors had to do with the many changes a student goes through.

Ross et al. (1999) used students as participants with many different majors, backgrounds, ages and so on. However, one can also focus more on specific groups of students. For example, international students who are from different backgrounds and cultures experience some stressors that are not found in students that study in their own country (Robotham and Julian, 2006). They experience more stressors related to language barriers, homesickness and adapting to a different culture.

Another way to focus on a specific group of students is to focus on one's major. The research of Radcliffe and Lester (2003) focusses on stressors for medical students. Apart from the same 'general' stressors, such as pressure for examinations and financial issues, medical students experience some stressors that were specific for their major, such as clinical training and internships in hospitals (Radcliffe and Lester, 2003). Another example of a research that focusses on a major is the research by Peluso et al. (2011). They researched stress and depression in psychology graduate students. Their research shows these students also showed stress during clinical training and counselling. Previous research proved that psychologists who experience a lot of stress and burn-outs lose the ability to empathize with their patients (Skorupa and Agresti, 1993). That is why it is important to provide solutions to students early on, on how to cope with stressful situations and regulate their emotions. This way, they know how to regulate their own emotions during their studies and in their future careers, and can prevent burn-outs, depression or other issues such as those related to stress.

2.2 Emotions

This section elaborates on the topic of emotions. Emotions are inherently connected to stress and coping with stress. Regulating emotions might help when trying to cope with stress. Because of this, some emotion regulation techniques are explained and the emotion regulation technique that will be used in this research, mindfulness, will be elaborated on.

2.2.1 Emotion and stress

At the beginning, stress was viewed as a simple one dimensional concept, which entailed a scale of low to high stress levels (Lazarus, 2006). There was no real division between different types of stress. Selye (1956) was the first to divide the concept of stress into *distress* and *eustress*. Distress stands for the negative notion of stress that is associated with emotions such as anger and aggression, resulting in feelings of revenge. Eustress is the opposite, positive form of stress, that is paired with empathetic feelings for other human beings and should be good for one's health (Selye, 1956). This division is still quite vague and has not empirically been proven, even though it is a popular theory.

The second researchers who divided stress into types of stress are Folkman et al. (1986). As explained earlier, they divided stress into threat, harm and challenge. With these types either positive or negative feelings were associated. However Folkman et al. (1986) did not specifically define what emotions can be associated with each type of stress.

As Lazarus (2006) argues in his book on stress and emotion, these different types of stress are mostly functional categories focussing on either positive or negative stress. They tell us little about the way a person struggles to cope with stress. However, emotions do tell us a lot more about the way one struggles with stress and how he or she tries to cope with it (Lazarus, 2006). Some people might feel sadness as compared to other people that might feel anger.

For quite some time stress and emotion were researched as two completely separate topics. However, stress and emotion are interdependent concepts that cannot be researched completely independently (Lazarus, 2006). When there is stress, there are emotions. In reverse, when there are emotions, there can also be stress, even though this is not always the case. Lazarus (2006) defines 8 *stress emotions* that arise from stressful situations: anger, sadness, shame, guilt, jealousy, anxiety, envy, and fright. In Table 1 the eight stress emotions are defined.

Lazarus (2006) notes in his book that there can also be positively toned emotions that can be stressful. For example, a person can experience happiness at the moment, but there can be an underlying anxiety for it to end, which can cause stress (Lazarus, 2006). However, when experiencing stress during positive emotions, they always seem to be paired with a (negative) stress emotion. In our example this is anxiety, because of an underlying fear for something bad to happen.

The emotions in Table 1 can appear alone or in different combinations during stressful situations. Per emotion, different coping strategies exist. For example, when feeling envious of someone, a coping mechanism is to imagine that that person is probably unhappy, even though they own what you want (Lazarus, 2006). Another example is gossiping about the person you envy, to make yourself feel better. An example for coping with anger could be to take revenge (Lazarus, 2006). These examples showcase that not all coping mechanisms are necessarily 'good'. Taking revenge might harm someone and perhaps produce feelings of guilt afterwards. This means the stress experienced is not always solved, even after trying to cope with the emotions that were felt. However, there exist proven methods of regulating emotions in a more efficient and positive way.

Emotion	Definition
Anger	When a person experiences a demeaning offence against him or her. The goal of anger is to preserve self-esteem and social-esteem.The cognitive appraisal that comes with anger is harm to oneself and the assignment of blame. This can either be harm by another person, or harm by oneself. The same goes for blame.
Envy	When a person wants what someone else has. If someone is envious, they compare themselves negatively to other people.
Jealousy	The definition of envy also applies to jealousy. However, the core of jealousy is resenting another person for the loss or threat of loss of something valued. When envious, you do not necessarily resent the other person, you just think of yourself more negatively.
Fright	When a person faces a sudden physical threat that is dangerous to his or her well-being.
Anxiety	A feeling of continuing unease, worry and anticipation. There is no immediate or concrete danger (yet) as there is with fright. An example of anxiety is the worry to and anticipation of a bad grade for an exam.
Guilt	When a person has violated a moral imperative. This violation can either be imaginary or real. If another person is harmed due to the violation, it will add to the amount of guilt a person is feeling.
Shame	Shame is very similar to guilt. It is also about personal failure. However, in shame people feel they fail to live up to a certain way they want to represent themselves. Their ideal social identity. This has nothing to do with the moral standards, like guilt does.
Sadness	When a person experiences an irreversible loss, in which there is no hope in restoring what is lost.

Table 1: Emotions defined

2.2.2 Emotion Regulation

As mentioned in Section 2.1.1, Folkman et al. (1986) defined two ways of coping that often appear together: problem-focused coping and emotion-focused coping. Problem-focused coping is practically oriented, since one wants to solve the problem at hand that causes a stressful situation (Folkman et al., 1986). For example, a dog suddenly starts barking at you from someones backyard. You are frightened and want to get out of the stressful situation. The problem-oriented approach would be to walk away from the dog to a save place. Now the 'problem' (the dog) that caused the stressful situation is no longer in sight, and thus the stimulus is gone. However, emotions tend to linger much longer, even after the stressful situation is resolved (Gross, 1998). Now emotion-focused coping comes into play. This is a much more complex process than problem-oriented coping. There are many different ways to cope with, or regulate, one's emotions. Before we get into different ways of emotion regulation, we first need to define the process.

Ross Thompson (1994) is a well renowned researcher on the topics of stress, emotion regulation and stress prevention. In his article 'Emotion Regulation: a theme in search of definition' he is the first to really define what emotion regulation is and all of it's core aspects. Since this concept was still quite a new field of research, there was a need to precisely define what emotion regulation is. Up until this day, Thompson's definition is still used in many researches on emotion regulation. Thompson (1994) defines emotion regulation as:

"Emotion regulation consists of extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying reactions, especially their intensive and temporal features, to accomplish one's goals. (Thompson, 1994)"

There are a few characteristics of emotion regulation involved in this definition.

Firstly, emotion regulation involves the enhancing, maintaining or decreasing the emotional arousal one is feeling (Thompson, 1994). Often we want to decrease the emotional arousal if the emotion is a 'negative' or a stress emotion, while we want to maintain or enhance a positive emotion. However, one might want to maintain or even enhance negative emotions in some cases. Thompson (1994) gives the example of a boy wanting to enhance his anger to be able to stand up against his bully.

Secondly, emotion regulation does not only entail one's self-management of emotions, but also external influences that help regulate emotions. Most emotion regulation actually occurs due to the interventions of others (Thompson, 1994). For example, parents often try to regulate the emotions of their children, to maintain their emotional well-being and incorporate certain cultural values and expectations in regards to emotions and feelings. As adults, we regularly try to regulate our emotions by asking for advice or finding someone who will just listen to you. This social part of emotion regulation is very important to acknowledge and something that shapes how a human manages one's own emotions (Thompson, 1994).

Thirdly, emotion regulation affects the intensity and temporal features of an emotion. Thus, emotion regulation can intensify or decrease the intensity of an emotion, while it can also affect the amount of time one is feeling such a emotion.

Finally, in the end, emotion regulation functionally is meant to meet a person's goals in a certain situation (Thompson, 1994).

2.2.3 Emotion regulation strategies

The definition of emotion regulation showcases that it is a complex process, in which endless emotion regulation strategies are possible. Gross (1998) came up with an emotion regulation process model, to create a division in the types of techniques that exist. He creates a distinction between *antecedent-focused strategies* and *response-focused strategies.*

Antecedent-focused strategies are things humans do before the emotional response is fully activated. For example, taking a walk before an exam to clear your head and rest, in comparison to studying until the last minute, while anxiety grows. These strategies are of a preventive nature (Gross, 1998).

Response-focused strategies are things humans do if the emotional response is already activated. For example, suppressing your fear of heights when friends ask you to go mountain climbing with them. These strategies always follow after an emotion is already activated.

Beneath these two broad categories, Gross (1998) tests two regulation strategies in his paper: *reappraisal* (antecedent-focused) and *suppression* (response-focused). Reappraisal is focused on changing the cognitive perspective or reinterpreting a stressful situation in a more positive way. Suppression, in case of Gross's model, is focused on the suppression of expressive emotions. From his experiments it appeared that reappraisal strategies had a positive influence on the emotional responses by participants. However, when participants were asked to suppress expressive emotions, they did succeed in suppressing the expressiveness of an emotion, but they still felt the (negative) emotion. It also appeared to have a different influence on the participant's memories. Negative experiences are often better remembered than positive experiences. When participants

reappraised a situation and their emotions, they often did not remember the negative experience well, because it was no longer viewed as a negative experience. In comparison, participants who suppressed their expressive emotions did remember the experience well, because they still viewed it as a negative experience (Gross, 1998). Jackson et al. (2000) also researched these two strategies, and reported the same results: reappraisal proved to be a better strategy in comparison to suppression of expressive emotions.

While Gross (1998) focused on suppressing expressive emotions, other researchers have focused on suppressing unwanted thoughts.Wenzlaff and Wegner (2000) researched this emotion regulation technique. Results showed participants actually increased the accessibility to these unwanted thoughts and showcased more sensitivity for anxiety and depression (Wenzlaff and Wegner, 2000). Suppressing unwanted thoughts thus made it easier to access these negative thoughts.

Apart from suppression, other emotion regulation techniques that proved to be risky and could increase anxiety and depression, are *avoidance* and *rumination* (Aldao et al., 2010). Avoidance can be categorized as an antecedent-focused strategy, because it tries to prevent a stressful response, through avoiding situations in the first place. It has been proven that avoiding experiences, physical and psychological, result in negative behaviour, such as binge-eating (Heatherton and Baumeister, 1991; Polivy and Herman, 1999). Next to this negative behaviour the fear and anxiety for the experience remains. Rumination is at the other end of this spectrum. Rumination is to constantly focus on one's mood and the implications of that mood on oneself (Hong, 2007). Rumination is a response-focused strategy, since it appears after a person feels a certain way. People who use rumination as a regulation technique often think focusing on their mood and problems will help solving them (Aldao et al., 2010). However, rumination often results in constantly focusing on how sad and lethargic one feels, while missing positive actual problem solving opportunities. It is one of the main factors that maintains depression (Hong, 2007).

Luckily, there exist some emotion regulation techniques that proved to have a positive impact on the mood and stress-levels of a person. Among them is of course reappraisal, that showcased a positive effect on mood and stress-levels (Gross, 1998; Jackson et al., 2000). Another emotion regulation technique that showed positive results is *problem-solving.* Problem-solving in itself is not necessarily an emotion regulation technique, but can certainly decrease stress and remove stressors (Aldao et al., 2010). Problem-solving are conscious attempts to change a stressful situation (Aldao et al., 2010). It is a response-focused strategy, since it appears after a situation has emerged. For example, a student is experiencing stress due to time pressure of multiple deadlines and exams. A problem-solving technique could be to create a plan in which he or she describes when to study for what, so there is a clear overview for that student to follow. Problem-solving is a major component in most cognitive and behavioural therapies (Beck, 1979; D'Zurilla and Nezu, 2010). Bad problem-solving skills have proven to lead towards mental illnesses, such as depression (D'Zurilla et al., 1998) and anxiety (Chang et al., 2004).

Another emotion regulation technique that showcases positive effects on mood and stress-levels is *acceptance.* Acceptance means to accept the emotions one is experiencing, without being judgmental about them. Acceptance is a response-focused strategy, because it is focused on accepting emotions that come to you, instead of preventing them from happening. Researches towards therapies using acceptance show positive outcomes (Heffner et al., 2003; Hayes et al., 2006). Low levels of acceptance showcase a higher probability of developing a mental illness, such as anxiety and substance use (Hayes et al., 2006). A well-known and well-researched acceptance technique is *mindfulness.* Mindful-

ness has proven to help regulate emotions in many different circumstances (Kabat-Zinn, 2003; Aldao et al., 2010). It has become quite popular to use mindfulness in therapy. Because of the positive outcomes when using mindfulness and it's current popularity, we will use mindfulness techniques to regulate emotions in this research. In the next chapter the topic of mindfulness will be further elaborated on.

2.2.4 Mindfulness

Mindfulness is at the core of Buddhism and Buddhist meditation. Mindfulness practices and meditations were used by Buddha to cure the fundamental disease humans suffer from: greed, ignorance/delusion and hatred (Kabat-Zinn, 2003). Mindfulness can be defined as:

> "The awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment. (Kabat-Zinn, 2003)"

Many societies in Asia have been practicing some form of mindfulness for centuries as part of their culture. However, mindfulness was slowly introduced in the west around the 70s (Kabat-Zinn, 2003). It fit the 'make-love-not-war' 70s culture in the west quite well. Around the 90s researchers started to pay more attention to these mindfulness practices and ideas. Society was opening up about daily stress and mental illnesses. Jon Kabat-Zinn was the first scientist to create a therapy fully based upon mindfulness practices that reduces stress and can help cure mental illnesses. This therapy program is called *The Mindfulness-based Stress Reduction (MBSR)* therapy. It is originally an 8-week group-program, in which participants intensively engage in mindfulness practices everyday, individually and in groups (Kabat-Zinn, 2003). It was originally only taught at The Stress Reduction Clinic to test whether this program would provide positive outcomes, which it did (Kabat-Zinn, 2003). Now many hospitals, clinics and psychologists use MBSR as a model to treat their patients, either in groups or individuals.

MBSR proved to be helpful in many different circumstances. Speca et al. (2000) showcased in their research that MBSR practices significantly reduced stress-symptoms cancer patients deal with. Bruckstein (1999) proved MBSR significantly lowered the pain patients with chronic pain illnesses were experiencing. Perkins (1999) found prisoners had significantly reduced stress levels and portrayed significantly less anger through using MBSR. Students also showcased significantly reduced stress-levels after taking part in the MBSR program (Felver et al., 2018). There are many more researches that prove MBSR is a mindfulness therapy that reduces stress and (the chance of developing) mental illnesses (Shapiro et al., 1998, 2005; Grossman et al., 2004; Shapiro et al., 2007; Rosenzweig et al., 2003).

After Kabat-Zinn (2003) came up with the MBSR therapy, more scientists decided to look into using mindfulness as a therapy to treat stress and mental illnesses. Teasdale et al. (2000) came up with the *Mindfulness-based Cognitive Therapy (MBCT)*, which was specifically meant to prevent recurrent depression. It contains the same objective of enhancing awareness, as MBSR does, but more specifically focuses on disengaging from repetitive negative thoughts (rumination) that often appear if one is depressed. MBCT has proven to be effective when used for preventing recurrence of depression (Fjorback et al., 2011; Teasdale et al., 2000; Gu et al., 2015). MBSR proved to be more efficient in reducing stress and overall mental health in comparison to MBCT (Fjorback et al., 2011). However, MBCT is specifically meant for the prevention of recurrent depression, in which it proved to be a more efficient method in comparison to MBSR (Fjorback et al., 2011).

Another popular therapy that uses mindfulness practices is *Acceptance and Commitment Therapy (ACT)* (Hayes et al., 2006). ACT is not necessarily based around mindfulness, but does use some mindfulness practices and techniques. ACT is based upon accepting feelings, distancing oneself from negative feelings ('I am having the thought that I am not good enough'), being present, using oneself as context, defining one's values, and committed action (Hayes et al., 2006). Unlike MBSR and MBCT, ACT is not designed to be an 8-week group program, but is designed to be used by psychologists on individuals. Additionally, ACT is focused on treating acute depression, in which is has proven to be successful (Hayes et al., 2006; Forman et al., 2007; Bohlmeijer et al., 2011).

As discussed, there exist different therapies that are based upon or use mindfulness, that prove to be successful. We have discussed the three most popular therapies: MBSR, MBCT and ACT. Because MBCT and ACT are primarily focused on depression, while MBSR is primarily focused on stress reduction, and MBSR has an enormous amount of effective research behind it, we choose to use MBSR mindfulness practices in this research.

2.3 E-health and digital intervention

The goal of this research is to design an algorithm that can be implemented in an application that helps students regulate their emotions and stress-levels. To be able to do this, it is also important to understand what digital solutions already exist. Up until this point we have discussed emotion regulation techniques and mindfulness therapies that are mostly executed face-to-face with professionals, such as psychologists and doctors. Face-to-face therapy is still, and probably will be for a long time, the best and most effective way to help people with their mental health. However, with the arrival of the internet, new opportunities arise, especially now that artificial intelligence is booming. Technology might not be able to replace face-to-face therapy with a professional, but it can support therapy and perhaps help with smaller problems. In this chapter we will take a look at existing digital solutions and interventions. We will also focus on adaptiveness and why it might be interesting to use this in an algorithm meant for regulating emotions and reducing stress.

2.3.1 Existing solutions

Digital interventions, or e-coaches, have been proven to succeed in the past in different (medical) areas. In fitness for example, it is has become quite normal to use a digital application that motivates people to work out or stick to their diet. The digital intervention is often presented in the form of an app that reminds and motivates people to move. These apps have proven to motivate people to work out and stick to their diet (Simons et al., 2013). Adhering to a diet and fitness regime was found to be significantly higher in people who use a smartphone application that provides a digital intervention during the day, in comparison to people who use a diary to manually track their progress and goals (Carter et al., 2013). However, it was found that many popular fitness apps lack evidence-based features and content (Rivera et al., 2016; Breton et al., 2011). The research by Levinson et al. (2017) even showcased that the popular calorie counting app 'My Fitness Pal' might contribute to an eating disorder. The app does not always provide the best caloric advice to it's users. To prevent a situation like this, it is important these types of digital intervention applications use evidence-based content and advise.

Another (medical) area digital interventions are being used is for people suffering from chronic diseases. For example, Wayne and Ritvo (2014) researched the effective-

ness of a digital intervention in poorly managed diabetic patients. They developed a smartphone application that coached these patients to measure their glucose and mental state every day. This app contributed to patients better managing their disease, but also doctors gaining a better overview and understanding of their patients, since they were allowed to see the data in the app (Wayne and Ritvo, 2014).

These digital interventions are mostly focused on a physical change (reminders to move or to measure glucose levels). Digital interventions for psychological issues and encouragement have become more popular only in the last decade. Wade (2010) did a systematic review of digital online interventions that existed at that time. He identified four different types of digital interventions he found:

1. *Information*: this category provides information about different illnesses. Mostly used in the form of an online website. Strengths of this category are that the information is always available and it may reduce personal beliefs and stigmas associated with a mental illness. Weaknesses of this category are that the information is hard to moderate and is not always entirely up to date. It is also not suitable for people who do not use the internet regularly.

2. *Screening/self-diagnosis*: this category provides ways to self-diagnose if a person is afraid they might suffer from a mental illness. An example is a digital test that tells you whether you might suffer from a mental illness. Strengths of this category are that it might encourage people to visit a therapist, which might improve efficacy in appointments and earlier treatment. Weaknesses of this category is that people might self-diagnose themselves wrongly or more often positively, which increases the workload for therapists.

3. *Therapy*: this category provides therapy and exercises through a digital medium, as well as supporting face-to-face therapy at home. Strengths of this category is that it can provide some extra support when in therapy for a mental illness, or it can help solve some more minor stress issues. However, weaknesses of this category are that it should not be used - on it's own - by people who are suffering from severe depression and/or who are at risk of suicide, as it might reinforce feelings of isolation and unimportance.

4. *Compliance support*: this category provides ways for a therapist to check whether a patient is following up his or her advice. Strengths of this category is that it could increase compliance and thus decrease symptoms of a mental illness. Weaknesses of this category are that it is often difficult to remotely measure the compliance of a patient and whether he or she has been truthful.

The category that we are particularly interested in, is the category of therapy, since we want to support students when they are experiencing stress, through providing mindfulness exercises. It is thus important to keep in mind what strengths and weaknesses are associated with this category.

There already exist some other evidence-based digital interventions that are focused on therapy. Mohr et al. (2017) for example developed an app suite, containing 14 apps, that is focused on treating depression and anxiety. The apps contain a combination of practices found in different evidence-based therapies, such as ACT. There is one main application called the IntelliCare Hub, in which users can choose to use one or more apps from 13 clinical apps. Each app has a different strategy and goal. For example, the app 'Social Force' prompts the user during the day to identify supportive people in his or her

life, and encourages him or her to keep in touch with these people. This way someone who is experiencing depression might open up more to trustworthy people in his or her life and does not become isolated as easily. The app suite was tested and showed positive results. Symptoms of depression and anxiety were largely reduced.

Another interesting example of a digital intervention to treat stress, anxiety and depression is the game-based intervention by Merry et al. (2012). Merry et al. (2012) designed the computer-based fantasy game SPARKX that uses practices from cognitive behavioural therapy, which also contains some mindfulness exercises. In the game users create an avatar and have to restore the balance in the fantasy world that is dominated by GNATs (Gloomy Negative Automatic Thoughts) (Merry et al., 2012). To do this, users have to complete quests that also contain exercises they must do, such as controlled breathing and cognitive restructuring. The game has been tested with teenagers aged between 12 and 19, and was compared to normal face-to-face cognitive behavioural therapy. The game proved to be just as effective as normal face-to-face therapy (Merry et al., 2012). It significantly reduced stress, depression and anxiety symptoms.

These examples showcase there can be many different ways in which a digital intervention is designed and implemented. The examples also show digital interventions can help in reducing stress, anxiety and depression symptoms. However, a digital intervention that adapts to the person using it, just like a therapist would adapt to his or her patient, is something that has become a topic of interest only recently. The app suite designed by Mohr et al. (2017) provides somewhat adaptiveness, because a user can choose apps based on their own goals. However, an application that adapts itself to the user based on certain characteristics might help a person in ways he or she did not notice themselves. Now that artificial intelligence has become a popular topic of research, it's practises are also used more and more in all kinds of applications. One of these practises is the ability to adapt to a user and provide a more personalized service. In the next chapter we will get into adaptiveness, different adaptiveness techniques and what applications already exist using these techniques.

2.3.2 Adaptiveness

In the last two decades, adaptiveness has become a popular topic of research. This started when the distinction between static hypermedia and adaptive hypermedia was made. In static hypermedia, the same links and the same content is presented to every user, while adaptive hypermedia systems build a model of goals, preferences and knowledge of each user, and adapts it's content to fit that particular user and it's environment (Brusilovsky, 1998). A simple, yet useful definition of an adaptive system is:

> "Adaptive systems are systems that automatically adapt to the user and/or their context of use"[1]

As seen in the definition on adaptive systems, there are two main factors to which a system adapts: the user and his or her environment/context. An adaptive system builds a user model of each user individually. This user model contains information about the user that is relevant for the system. (Brusilovsky, 1998) categorizes six types of information that an adaptive system can collect about a user: *goals/tasks*, *knowledge*, *background*, *preferences*, *interests*, *individual traits*. Goals and tasks are about what the user's goals are and what tasks he or she needs to do to reach those goals. Knowledge is about the level of knowledge a user has on a certain topic, that is relevant for the adaptive

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[1]Definition by lecturer and advisor Judith Masthoff

system. For example, an adaptive tutoring system should know the level of knowledge of the user on a certain topic, so the system can adapt it's exercises to that level of knowledge. Background is information on the background of a user, such as cultural background or mother tongue. Preferences is about certain preferences a user has. For example, an adaptive music player wants to know what type of genre the user prefers, so it can adapt to that music style. Interests is about certain interests a user has. For example, if a user clicks on a book in an online bookshop, other books that might be interesting for the user are recommended to him or her. Individual traits is about traits such as personality or learning styles. These types of traits cannot be changed or change only over a long period of time (Brusilovsky, 1998). Ways a system can adapt to a user model are endless. For example, an application run on a device using touchscreen can adapt it's interface to a user who is blind or a user that has bigger fingers which makes it hard for him or her to tap small icons. Another example is basing a radio station off of a playlist made by a user, something Spotify (a popular music-streaming app) uses a lot. This way users get to know new music that fits their taste.

However, how can the system obtain all these types of information from the user? And what should happen when the user uses the system for the first time, when the system does not know anything about the user just yet? There exist different methods on starting out with no information and methods on how to obtain information. The system can start out with zero information about the user and just start observing the user's behaviour. Behaviour that is observable is for example mouse clicks, the amount of time spend on one page, a product bought by a user and so on. However, this "cold start" might not be the most efficient way to obtain information about a user. It takes a long time to get to know the user and what do mouse clicks really tell us?

Another method that can be used with new users, is the use of *stereotypes*. People use stereotypes every day. Even though it is a habit we often try to restrain, it is something our brains do regardless. The reason we use stereotypes is because our brains are trying to make sense of and try to simplify our complex world (Rich, 1979). We humans often also start by using a stereotype for someone we meet, which is refined into a more complex mental model of that person in our brains after getting to know them better (Rich, 1979). For example, a stereotype about the Dutch is that they all smoke weed, because that is legal in The Netherlands. However, when getting to know the Dutch, many people will come to realize the majority does not smoke weed on a regular basis. Thus, the mental model about Dutch people is refined. This mental model is similar to a user model. However, obtaining information about a person is much more difficult for a user model in comparison to a mental model. Humans can pick up verbal and non-verbal cues that already tell them a lot about a person, without knowing very specific information about them. This is much harder for a computer system to do, because it does not possess the same senses. However, there are ways in which a computer system can use stereotypes and refine a user model after it has obtained more information. These stereotypes need to be pre-programmed. Stereotypes can be based on many different criteria that are relevant for the application. For example, one can use personality type, affective state or physical state as stereotypes. To determine a stereotype, a user can be asked a few questions before using the application. Another way to determine a stereotype is to ask for feedback (for example, to rate an item or activity the system recommended to a user). Asking for feedback also helps in refining the user model for a person, because the system gets to know individual preferences, rather than only stereotypical. In this research we will also be using stereotypes in user modeling.

Next to the user itself, the system also adapts to the user's environment or con-

text. Just like user modeling, an environment can entail many different things. For example, a system can adapt to the device it is used on; a responsive website adapts to the size of the screen it is viewed on. Another example of an application that adapts to it's environment is Google Maps. If a user is using the navigation in the app past sun down, or if the device senses a level of darkness, the app will automatically adapt to this by switching to night mode, which changes the navigation to darker colors so users will not be blinded. An app that is very much based on adapting to environment is Happn. This smartphone dating app showcases possible love interests you have crossed paths with that might be interesting for you, based on your preferences. There are multiple ways for an adaptive system to get information about the environment of a user. Schmidt and Van Laerhoven (2001) have collected quite an extensive list of ways to collect data about the environment. Oftentimes this is done through the usage of sensors. In table 2 a part of the list by Schmidt and Van Laerhoven (2001) is given, to showcase an example of the vast amount of possibilities in this area.

Sensor	Description
Light sensor	Supplies information on light density, reflection, color temperature and type of light.
Camera	Vast amount of information can be acquired, such as motion, detection of people and objects, detecting gestures and so on.
Audio and Microphones	Supplies information on noise level and what type of noise (music, speaking). Can be used for speech recognition for example.
Accelerometer	Supplies information on motion and speed. For example, due to an accelerometer a device 'knows' whether it is laying still on a table or it's owner is walking and thus in motion.
Location	Supplies information on the location of the device and proximity of users and devices in the area. Using location one could also calculate for example the average walking speed of a user.
Touch	Can be used as a way to communicate with a device (through the use of a touch-screen for example), but can also supply information about for example fingerprints.
Temperature	Supplies information about temperature. For example, sensing the average temperature in a room or sensing body heat temperature in cold areas to prevent undercooling.
Bio-sensors	Supplies information on personal biological properties. For example, blood pressure, skin resistance, blood sugar levels and so on.

Table 2: Examples of sensors

2.3.3 Recommender systems

We have now seen how user models and environmental models are build and what can be used to gather information about a user and his or her environment. Once this information

is collected we can use it for multiple purposes. One of the most popular purposes is to use this information for recommendation. Humans already use recommendation in every day life. For example, we ask friends to recommend us a good restaurant, film, tv-series, book, recipe, and so on. Nowadays webshops and other service providers use recommendations in their systems and on their websites. A *recommender system* can be defined as:

> "Recommender Systems are software tools and techniques providing suggestions for items to be of use to a user (Ricci et al., 2011)"

In this definition "items" refers to anything that can be recommended to a user (Ricci et al., 2011). Recommendations are mostly focused on individual users that lack the experience or competence to evaluate the overwhelming amount of items a system or website can offer. Companies that use recommender systems use the systems for various reasons (Ricci et al., 2011):

1. Recommender systems in a commercial setting have proven to increase the number of items sold. Often additional recommended items are sold to customers. Next to this, recommender systems that are not used in a commercial setting have proven to also positively increase the use of an item. For example, a blogging-website aims to increase the number of articles read by a user. Recommender systems proved to increase the number of articles read by users.

2. Recommender systems have also proven to diversify the items that are sold/used. For example, a music streaming service such as Spotify can recommend less popular songs to a user, based on a popular song he or she likes.

3. Recommender systems also improve user satisfaction. If the recommender system has recommended some good recommendations to a user, he or she will become more curious towards other recommendations and will use the system more often.

4. Recommender systems increase user fidelity. Since recommender systems use previously acquired information about a user, it can recognize a customer and treat him or her as a valueable customer.

5. Recommender systems help companies to better understand what users want. This information helps companies in improving several parts of the company, such as stock management and advertisement management.

Thus, recommender systems often add something positive to a company, website or service. In the beginning, recommender systems where mostly used for commercial purposes, such as selling more items. It was focused on the company's profits. However, nowadays recommender systems are also used in services that do not care for profit. Farzan and Brusilovsky (2006) for example implemented a recommender system in a university course catalogue which recommended students courses for the next period based on a few attributes. It was positively reviewed by the students who used the systen (Farzan and Brusilovsky, 2006). In health care it is used by doctors as well as patients (Sezgin and Özkan, 2013; Wiesner and Pfeifer, 2014). Patients can use recommender systems to get recommended correct information about an illness, because it has been ranked highly by other users (Sezgin and Özkan, 2013). Doctors can use recommender systems to help them diagnose a patient (Sezgin and Özkan, 2013; Wiesner and Pfeifer, 2014). For example, a doctor has doubts whether a patient has either one or the other illness. In this case, the doctor can input the symptoms the patient is suffering from in a recommender

system. The system is filled with previous information about correct diagnoses of illnesses and their symptoms. It can provide the doctor with the most likely illness, based on symptoms and patient history.

As for how to cope with stress and mental health issues, there are not many evidence-based applications that use recommender systems, apart from websites that provide information through the use of articles. Most smartphone applications that focus on mental health use techniques such as tracking emotions, keeping a diary, providing information about meditations and exercises, and show therapists in the area. Examples of applications that use these techniques are Moodpath and Pacifica. These apps are both downloaded at least one million times and are reviewed well by users. This showcases that smartphone apps that do not necessarily are focused around recommender systems already help people with their mental health.

A Smartphone app that does use an evidence-based recommender system, is the app Youper. This app is based around a chatbot which asks the user questions and based on the information it receives gives advice or exercises that might help. The app is based upon Cognitive Behavioural therapy, ACT and Mindfulness. Thus, it incorporates different evidence-based theories. The user mostly communicates with the chatbot through choosing from a few pre-defined answers. Youper is an application in which such an algorithm we intent to design could be implemented. Youper already offers personal recommendations, however they could be made even more specific for students.

2.3.4 Recommendation techniques

There are multiple techniques a system can use to recommend an item to a user. To be able to recommend an item to a user, the system must predict or *filter* what item that individual user is most likely to buy or use (Ricci et al., 2011). Without this prediction step, the system could also just recommend the most popular items to everyone. In this case it is no longer an adaptive system that looks at each user individually. According to Ricci et al. (2011) there are roughly six main techniques of recommendation a system can use:

1. **Content-based filtering**: this type of filtering recommends similar items to a user, based on items he or she liked in the past. This similarity is based on certain features of the item. For example, the system can recommend books to a user, based on a book he liked in the past that was of a particular genre or author.

2. **Collaborative filtering**: this type of filtering recommends items to a user which where liked by other user with similar taste. The similarity in taste is based upon similarity in rating history of users. This is the most popular recommendation technique that is used nowadays.

3. **Demographic filtering**: this type of filtering recommends items based on demographic information about the user. This technique is often used in websites that are marketed towards a particular demographic niche.

4. **Knowledge-based filtering**: this type of filtering recommends items based on domain knowledge about certain items and/or it's features. In the end the recommended item should be useful for the user. The system estimates how much information the user needs and matches the recommendations based on that.

5. **Community-based filtering**: this type of filtering recommends items based on preferences of the user's friends. This filtering technique is based upon the evidence that people tend to trust friend's recommendations more in comparison to recommendation from strangers.

6. **Hybrid recommendation**: this type of filtering is a combination of the above mentioned techniques. Often one uses a combination of techniques to use advantages from one technique and simultaneously solve the disadvantages of the other technique.

2.3.5   Personality

The goal of this research is to create an adaptable algorithm that recommends the right mindfulness exercises to the right person. To be able to do this we will make use of a recommender system. To avoid a cold-start, which means when the user first starts using the application we do not have any information about the user to base recommendations on, we will use stereotypes. However, stereotypes can be based on many different types of information about the user. As mentioned before Brusilovsky (1998) categorized six types of information: goals/tasks, background, preferences, interests, and individual traits. We will primarily be using three of these types, namely goals/tasks, preferences and individual traits. To start off on a stereotype, we will look into the individual trait *personality*.

Personality and coping with stress have been researched and linked to each other numerous times. Watson and Hubbard (1996) mention in their article that personality and coping behaviour are not the same thing, but are structurally and conceptually closely linked to each other. They are part of the same adaptational continuum. Multiple researches showcased how different types of personalities continuously seemed to use the same coping strategies when experiencing stress. People that possess the trait of neuroticism for example tend to use more emotion-focused coping strategies, such as avoidance and emotional venting, as opposed to problem-focused coping strategies (McCrae and Costa Jr, 1986; Watson and Hubbard, 1996; Penley and Tomaka, 2002). In comparison, people who possess the trait of extraversion tend to use more problem-focused coping strategies, such as planning or rational action, as opposed to emotion-focused strategies (McCrae and Costa Jr, 1986; Penley and Tomaka, 2002). Thus, if we want to recommend the right mindfulness exercise to the right person, we might want to start by assessing what personality traits they possess.

However, what personality traits exist and how can we discover what traits a person possesses? Most researches that look into personality and coping strategies use the well-known *Big Five* personality dimensions, because there is an extensive body of research based around them and they are universally applicable in every culture (Judge et al., 1999). McCrae and Costa Jr (1986) conceptualized the Big Five dimensional personality model. The model consists of five different personality dimensions that a person belongs to to a greater or lesser extent. The five dimensions are: *neuroticism, extraversion, agreeableness, openness, and conscientiousness*. In table 3 all five dimensions are defined as described by McCrae and Costa Jr (1986) and Penley and Tomaka (2002).

There are many different ways one can measure the extent to which dimensions a person belongs. The most comprehensive and complete measurement is the NEO-Personality-inventory by Costa and McCrae (2008). This instrument consists of 240 items which takes about 45 minutes to complete. Because of it's lengthiness, other scales are often used to measure the big five dimensions. Shorter instruments are a 44-inventory scale (John et al., 1991) and the compressed version of the NEO-Personality-inventory

Dimension	Description
Neuroticism	Personality traits that belong to this dimension include a tendency to experience anxiety, self-pity, tension, self-consciousness, irrational thinking, impulsivity, hostility, low self-esteem, and depression.
Extraversion	Personality traits that belong to this dimension include a tendency to be positive, energetic, assertive, talkative, social, and warm.
Openness	Personality traits that belong to this dimension include a tendency to be curious, insightful, creative, flexible, intellectual, and original.
Agreeableness	Personality traits that belong to this dimension include a tendency to be forgiving, generous, kind, compliant, trustworthy, sympathetic, and altruistic.
Conscientiousness	Personality traits that belong to this dimension include a tendency to be organized, reliable, self-disciplined, efficient, rational, and deliberate

Table 3: The Big Five personality dimensions

consisting of 60 items (Costa and McCrae, 2008). These scales take about 5 to 10 minutes to complete. However, since smartphone applications have become incrementally more popular to use for all types of purposes, a survey consisting of 44 items would already be considered a hassle. Gosling et al. (2003) have designed 5 and 10 item instruments to measure the big five dimensions in a person, both only taking up 1 minute to complete. Of these two instruments, the 10 item measure is most accurate. Since it so short, but still accurate, we will be using the 10-item instrument by Gosling et al. (2003).

3 Research Method

The goal of this research is to design an adaptive digital intervention in the form of an algorithm that helps students regulate their emotions in order to cope with stress. To design this algorithm, some information needed to be acquired first. Such as, what stressors do students currently experience, specifically Dutch students, since the experiments are performed in The Netherlands. Next, personality needed to be combined with these stressors, because this combination of stressor and personality would also be used in the algorithm, to determine what mindfulness exercises are useful to recommend. Thereafter, therapists were interviewed on their expertise about what mindfulness exercises would be appropriate for what stressor and personality. Based upon this, the algorithm was designed, and finally the algorithm was tested. In the next subsections these activities will be explained upon in more detail. In most studies the results are already portrayed, because the next study builds upon the results of the previous one.

3.1 Study 1: Collecting Stressors

In section 2.1.3 some stressors students experience were explained. They were primarily focused on the many changes in life if one becomes a student, but also more in depth on stressors specific for internationals or certain majors. However, for this research I wanted to know what stressors Dutch students specifically experience, since the research is performed in The Netherlands. Since there are, to my knowledge, no articles that specifically look into stressors that Dutch students experience, I have collected some stressors through the use of focus groups. The next sub sections will describe how these focus groups were performed.

3.1.1 Participants

A total of 10 participants participated, equally divided over two focus groups. The participants were all students between the ages of 20 and 25. All participants identified themselves as female. There was a wide range of different majors, some examples are: Veterinary Science, Psychology, Creative Business, Sustainable Business, Social Work, Medical Science and so on.

3.1.2 Method

A total of two focus groups were performed. The focus groups took place in a meeting room at Utrecht University. The meeting room was quiet and it contained a table all participants took place at. In both groups 5 different participants participated. Before starting the focus groups, participants were handed an information sheet about the research, and were asked the fill out some demographic questions and sign the informed consent. The information sheet, informed consent and demographic questions can be found in appendix A. Both focus groups were recorded, so discussion and other remarks were captured for later use in results. After all participants filled out the required forms, I shortly explained the stressor categories by Kindness (2014). I told the participants that it would be nice if they could come up with stressors that belong to one of the categories. However, if they were unsure to which category a stressor belongs, that was no problem whatsoever, because we could discuss it or I could eventually decide to which category it might belong. Subsequently, I wrote all seven categories in thick black marker on separate sticky notes. The sticky notes were placed on the table with sufficient space between

them. Other sticky notes were then handed out to the participants. The participants were instructed to write down the stressors they came up with on a sticky note, and place the sticky note next to the category it belongs to, according to the participants.

3.1.3 Results

Both sessions lasted about half an hour. A total of 60 stressors was collected from the focus groups. Some stressors are very similar to others, which will eventually be filtered out in the validation of the categorization of stressors. Most students felt quite comfortable talking about stressors they experience. One student even asked whether only 'healthy' participants were needed. She clarified this question by revealing she was currently dealing with depression, and thus was not a mentally 'healthy' participant. Of course she was allowed to partake in the focus group. It did not matter whether a participant was suffering from mental health issues or not.

In table 4 the results are portrayed, ordered by the category to which participants assigned the stressors to.

Category	Stressors
Mental demands	- The feeling of not being good enough (either academically or personally), and thus trying harder to better myself. - Anxiety shortly before and during the exam makes me feel sick, which makes it very hard to focus. - Trying to keep up with my personal time schedule. - The whole concept of studying is mentally challenging for me. Going to lectures, self-study at home, the need for a social life etc. I have some burn-out symptoms because of this. - Having to focus on less interesting assignments. - Always being prepared for lessons and patients that are coming up. - Going through difficult study material that is hard to understand. - Feeling the pressure of other people expecting me to do well. - Finding a job is mentally challenging for me. Always searching for vacancies, writing motivation letters and so on. - The pressure to do many different things and be the best at it during your studies to be able to obtain a good job.

Physical demands	
	- The societal pressure of being slim and skinny (Instagram).
	- Feeling sick but still having to go to work or lectures, because you have to to be able to pay for everything and get good grades.
	- Finding the correct room in which the exam takes place in time.
	- Due to bad time management, I sometimes must bike really fast to work.
	- Biking to the train station is sometimes stressful if I am late.
	- One lecture in the morning and one lecture in the evening on the same day, meaning I either have to bike four times or stay at uni all day.
	- Getting ill, but not having the time to be ill and get better, because you have to do things.
	- Going to uni for lectures if the weather is bad.
	- Being an intern at the hospital all day can be physically demanding, running around helping patients.

Emotional demands	
	• I feel like I can't open up 100% to certain people and that is stressful.
	• To have to act normal during the day while I had a fight with a friend/boyfriend that is bothering me.
	• Going somewhere because of the fear of missing out.
	• Groupwork can be very stressful when there are conflicts with teammates (and you still have to be polite to one-another).
	• Trying to communicate with my grandmother who is suffering from dementia.
	• Working together with other students can be challenging.
	• Presenting in front of the class is socially and emotionally challenging for me, because everybody is looking at you and I feel the pressure to present well (not too fast, not too slow) and be interesting.
	• Put up a nice smile and be cheerful during activities at my student-association, even if I don't feel like it.
	• Having to meet friends occasionally. I like meeting them, but sometimes it feels demanding when I am very busy.
	• Being expected to be happy and interested all the time.
	• Being 'involved' with friends and making conversation and asking about others etc.
	• Always having to be nice to patients, even if they don't treat you that way.

Frustration	
	• Receiving a bad grade, when you were expecting a good one.
	• Taking the bus during rush hour. Often there is delay and too many people.
	• When assessors have different ideas of how the assignment should be, that makes me feel frustrated, confused and lost.
	• Delayed trains are very frustrating.
	• Economic cuts that hit students and teachers. Protesting barely works, so it is frustrating nothing happens.
	• Too much subject matter.
	• A high study debt.
	• Students who keep getting up and making noise in the University Library.
	• Customers in the restaurant I work at sometimes forget what they ordered and expect me to know it. That is frustrating.
	• Also customers who are very demanding and rude to me.
Temporal demands	
	• The time pressure of deadlines.
	• The pressure of trying to fit everything in my schedule: sports, study, student association, friendships, work, and so on.
	• When lectures are during mid-day, which means there is no useful time left before or after the lectures.
	• The time pressure of studying for exams.
	• The time pressure of being on time for appointments.
	• The time pressure of having to read a lot of articles in a short period of time.

Isolation/loneliness	
	• I'd like to speak Dutch, but since I don't, sometimes I feel isolated.
	• I sometimes feel more pressure because of my studies than other students seem to feel. That makes me feel lonely.
	• Because of the different courses every period, there are different people every time in lectures. That makes it really hard to get to know your fellow students. That makes me feel isolated and lonely, even during lectures.
	• When friends seem to be much closer to each other than they are to me I feel lonely and isolated.
	• When people have made plans without me.
	• When I am home alone I feel lonely.
	• When I get the feeling I have to put in a lot of effort to belong to a group of people, that makes me feel lonely and isolated.
Interruption	
	• Students who keep chatting during a lecture.
	• Students who do completely different things on their computers during lectures, which are distracting (for example scrolling through social media, or watching movies).
	• If someone calls me when I am studying, it is very hard to get back to studying.
	• Netflix feels like an interruption sometimes when studying.
	• Having to prioritize things (because of deadlines) even though personally I have other priorities I'd rather be doing.

Table 4: Stressors collected in focus groups

3.2 Study 2: Validation of Stressor Categories

A total of 60 stressors was collected. These stressors were already distributed over the seven categories by the participants. The categories are needed to use in the algorithm for adaptation. It is thus important to validate whether this categorization by participants

is valid.

3.2.1 Participants

For the validation of the categories, participants were collected from the website SurveySwap.io. At this website one can post a survey which random participants can fill out. However, in return, you also have to fill out surveys for others. Because random participants were needed for the validation, this website seemed to be a good option. In total, 22 participants participated in the validation. Five participants identified as male, while 17 participants identified as female. The mean age was 24 years old.

3.2.2 Method

The stressors that were collected in study 1 were all written down in table 4 just as participants wrote them on the sticky notes. To be able to validate the categorization of the stressors, they needed to be converted to a more unified writing style. As seen in table 4 some stressors contain the word 'I' and others do not. To create a unified way of presenting the stressors to participants that will validate the categorization, I followed Kindness (2014)'s validation design. Kindness (2014) converted the stressors to stories about a caretaker. It is easier for people to empathize with a character in a story in comparison to the sentence beginning with 'I' or no character at all (Kindness, 2014). For this reason, the collected stressors were converted to stories about a student named 'John', a simple and frequently used English name. For example, the stressor "To have to act normal during the day while I had a fight with a friend/boyfriend that is bothering me." was converted to "John had a fight with his girlfriend before class. Now he must act normal among his fellow students, while he does not feel happy.".

Apart from converting the stressors to stories about John, we also tried to eliminate words that very clearly portrayed to which category a stressor belongs. For example, the stressor "I'd like to speak Dutch, but since I don't sometimes, I feel isolated." was converted to "John is studying in the Netherlands. He would like to speak Dutch, but since he does not, sometimes he feels excluded from his fellow students.". In the example, it was clarified that John is an international who is studying in The Netherlands but does not speak Dutch. Next to this, the word "isolated" was changed to "excluded", because isolated is also in the name of the category itself, and excluded is synonymous for the word isolated. However, in some cases it was impossible to change certain words that clearly portrayed to which category they belong, because they were at the core of the stressor. For example, in the category of temporal demands, most stressors use the words "time pressure". It was not possible to remove these words or change them into something else, because time pressure is often at the core of these stressors. In appendix B all converted stressors are portrayed.

Another important change, is the change of the name of the category "emotional demand". Every stressor that was mentioned by the students that participated in the focus groups, that belonged to this category, had a very social aspect to it. Students asked during the focus groups if I could explain the emotional demand category again, and how it is different from the mental demand category. Some felt emotional and mental demand were quite similar. I explained to them emotional demand is when you feel you need to force yourself to feel and express a certain emotion in a situation, while mental demand is if one does something that is challenging for the mind. Because of this confusion in the focus groups and because most stressors that are in the emotional demand category are socially oriented, it was decided to change the name of the category

to "social-emotional demand", in hopes this would clarify the difference between mental demand and emotional demand more.

Once the stressors were converted to stories about John, a survey was created. The survey was made using Qualtrics. At first participants would need to read the instructions and information about the different types of categories. The instructions can be found in appendix C. Next, participants would have to fill out their age and choose what gender they identify with. For gender the options consisted of 'male', 'female', 'other', and 'prefer not to say'. This is the only demographic information that was collected about the participants, because it was not necessarily important that participants were of a certain age, gender or any other characteristic, but it is good to have somewhat of an idea of who participated in the survey. Thereafter, followed a total of sixty questions, presented as seen in figure 1 participants were asked to choose only one category to which they think a stressor belongs to. The categories are explained in the instruction and information page at the beginning of the survey, however, beneath every category in the questions a short explanation of every category is also presented so participants do not have to remember the explanation to each category. Apart from the seven categories, participants can also choose for the eight option: 'Other'. This option was added, because some participants might find some stressors do not belong to any category or perhaps to multiple categories.

3.2.3 Results

To be able to validate to which categories the stressors belong, the Free-Marginal Kappa designed by Randolph (2005) was used. The free-marginal kappa is specifically meant to measure the amount of agreeableness between participants who are supposed to distribute cases across categories (Randolph, 2005). In this case, stressors are to be distributed over the seven categories and the 'Other' option. The values of this Kappa can range between -1.0 and 1.0. -1.0 indicates a perfect disagreement below chance, 0.0 indicates agreement equal to chance, and 1.0 indicates perfect agreement above chance. For the free-marginal kappa a value below 0.4 indicates poor agreement, a value between 0.4 and 0.75 indicates intermediate to good agreement, and a value above 0.75 indicates excellent agreement (Randolph, 2005). Table 5 showcases the results of the survey validation. The table shows the free-marginal kappa, the percentage of overall agreement and the number of participants that voted a stressor to a certain category. For categories that have a free-marginal kappa of 0.4 or above the category that was most voted for is displayed in bold numbers. The names of the categories were shortened to make the table fit better on the pages.

John is a student. What stressor is John experiencing? Choose one option only.

"John must prioritize certain things (because of deadlines) even though personally he has other priorities he'd rather be doing."

Physical demand (any stressful physical activity that is demanded of a person)	**Frustration** (the feeling of frustration or annoyance that happens due to an activity)
Mental demand (any kind of stressful mental activity that demands a lot of thinking)	**Isolation/Loneliness** (the feeling of being alone and isolated from other people)
Temporal demand (any kind of stressful time-related demand)	**Interruption** (when interruption is causing stress during an activity)
Social-Emotional demand (any kind of emotion that is demanded in a certain situation, that can be stressful)	**Other**

Figure 1: Example of a survey-question

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
Because of the different courses every period, there are different people every time in lectures. That makes it really hard for John to get to know his fellow students. That makes him feel alone, even during lectures	0.71	74.46%	0	2	0	0	0	19	1	0
John is an intern at the hospital; he has to run around helping patients	0.62	66.67%	18	0	2	1	1	0	0	0
John notices his friends seem to be much closer to each other than they are to him	0.62	67.10%	2	0	0	2	0	18	0	0
John is going through difficult study material that is hard to understand	0.61	66.23%	0	18	1	0	1	1	0	1
While John is studying for his exam, his mother calls	0.61	66.12%	0	1	1	0	1	0	18	1
While John is studying for his exam, he receives a notice from Netflix about new episodes of his favorite show	0.61	66.23%	0	1	1	0	1	0	18	1
John is home alone	0.56	61.47%	0	0	0	1	0	17	0	4
John feels he has to put up a nice smile and be cheerful during activities at his student association, even though he does not feel like it	0.54	59.74%	2	2	1	17	0	0	0	0
John feels the time pressure of deadlines	0.54	60.17%	1	3	17	0	1	0	0	0
John is studying in the Netherlands. He would like to speak Dutch, but since he does not, sometimes he feels excluded from his fellow students	0.54	59.74%	1	2	0	2	0	17	0	0

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
John is doing an internship in a hospital and feels he must be nice to patients, even if they treat him badly	0.53	59.31%	0	1	0	**17**	2	0	1	1
John thinks he feels more pressure because of his studies than other students feel, making him feel like he is the only one	0.53	58.87%	0	1	1	1	1	**17**	0	1
John feels he must be 'involved' with friends and always make conversation with them	0.47	53.68%	0	3	0	**16**	0	2	1	0
John fears missing out, because he cannot join his friends in the bar	0.46	52.81%	0	0	1	2	2	**16**	0	1
John feels the time pressure of being on time for a friend's wedding ceremony	0.46	52.38%	2	0	**16**	0	1	1	1	1
John feels the time pressure of having to read many articles in a very short period of time	0.43	49.78%	0	5	**15**	0	0	1	1	0
John feels the time pressure of studying for exams	0.41	48.05%	0	4	**15**	1	1	0	0	1
Fellow students have made plans without John	0.39	46.32%	0	1	1	2	2	15	0	1
John is following a lecture, but some students are doing completely different things on their computers during the lecture, which is distracting him	0.39	46.32%	0	0	2	0	6	0	14	0
John had a fight with his girlfriend before class. Now he must act normal among his fellow students, while he does not feel happy	0.38	45.89%	1	1	1	15	0	1	1	2
John has the feeling he has to put in a lot of effort to belong to a group of people	0.38	45.89%	0	1	0	14	1	6	0	0

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
John feels like he can't open up 100% to certain people and that is stressful	0.36	43.72%	0	0	1	14	0	5	1	1
John must find the correct room in which the exam takes place in time	0.34	41.99%	1	3	14	0	1	0	0	3
John is ill, but he does not have the time to be ill and get better, because there are tasks he has to do	0.34	42.42%	14	0	4	1	0	1	2	0
John is trying to keep up with his personal time schedule.	0.33	41.13%	2	3	14	0	1	1	0	1
John must focus on less interesting assignments.	0.33	41.56%	1	14	0	2	3	0	0	2
John is feeling sick but still must go to work or lectures, because he needs to be able to pay for everything and get good grades	0.33	41.13%	14	3	1	2	1	0	1	0
John has to give a presentation. He finds presenting in front of the class quite challenging, because everybody is looking at him and he feels the pressure to present well and be interesting	0.33	41.13%	1	2	3	14	0	1	0	1
While John is studying in the University Library, some students keep getting up and making noise	0.33	41.56%	0	0	0	0	6	3	13	0
John feels it is expected of him to be happy and interested even though he is not	0.29	38.10%	1	5	1	13	1	0	0	1
John is following a lecture, but some students are chatting during the lecture	0.29	38.10%	0	0	2	1	7	0	12	0

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
John feels the pressure of other people expecting him to do well.	0.27	36.36%	1	8	0	11	0	0	0	2
John has one lecture in the morning and one lecture in the evening on the same day, meaning he must cycle four times as he does not like to stay at Uni all day	0.27	36.36%	12	0	3	0	6	0	0	1
John received a bad grade, while he was expecting a good one	0.23	32.47%	0	3	1	1	12	1	0	4
John is aware that economic cuts hit students and teachers. He has attended many protest marches on this issue, but nothing has happened as a result	0.23	32.90%	2	0	0	3	12	0	1	4
John finds groupwork very stressful because there are conflicts with his teammates	0.22	31.60%	1	0	2	9	9	1	0	0
John is doing an internship in a hospital and must be prepared for lessons and patients that are coming up	0.21	30.74%	2	12	2	1	3	0	1	1
John must study too much subject matter	0.21	31.17%	2	11	2	0	0	0	1	6
John has the feeling he is not good enough academically, and thus trying hard to better himself.	0.20	30.30%	1	11	0	6	1	1	1	1
Due to bad time management, John must cycle really fast to his part-time job	0.20	30.30%	9	0	8	1	4	0	0	0
The train John takes every day to get to university is delayed	0.20	30.30%	0	1	8	0	9	0	4	0
John must take the bus during rush hour; there are delays and the bus is very crowded	0.18	28.57%	2	1	8	0	9	0	2	0

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
John's assessors have different ideas of how the assignment should be assessed, which confuses him	0.18	28.57%	1	9	0	2	8	0	0	2
John feels the societal pressure of being slim and skinny	0.17	27.71%	9	1	0	8	1	1	1	1
John feels working together with other students in his team challenging	0.17	27.71%	0	1	0	10	6	3	0	2
John is about to take an exam; he normally experiences anxiety shortly before and during exams that makes him feel sick, which makes it very hard to focus	0.16	26.41%	7	9	3	1	2	0	0	0
Today John has lectures during mid-day; he feels there is no useful time left before or after the lectures	0.16	26.84%	0	0	6	0	9	0	2	5
John has the feeling he is not good enough personally, and thus trying hard to better himself.	0.15	25.97%	1	7	1	9	1	0	0	3
Customers in the restaurant John works at sometimes forget what they ordered and expect him to know it	0.15	25.54%	1	8	0	1	8	1	0	3
John feels pressure to do many different things and be the best at these things during his studies, to be able to obtain a good job	0.14	24.68%	4	9	1	1	1	0	0	6
A customer at the restaurant in which John works has been very rude to him	0.12	22.94%	1	2	1	7	8	0	0	3

Stressor	Free Marginal Kappa	Percentage of overall agreement	Phys	Ment	Temp	Soc-Emo	Frus	Iso	Inter	Other
Finding a job is challenging for John: searching for vacancies, writing motivation letters and so on	0.11	22.08%	2	9	3	1	5	0	0	2
John has a hard time trying to communicate with his grandmother who is suffering from dementia	0.11	22.08%	0	1	1	7	8	2	1	2
John must go to Uni, but it is raining very heavily	0.09	20.78%	7	1	3	1	7	0	3	0
Cycling to the train station is stressful because John is late	0.08	19.91%	6	2	8	0	2	1	2	1
The whole concept of studying is challenging for John: going to lectures, self-study at home, the need for a social life and such.	0.05	16.88%	5	7	4	2	2	1	0	1
John feels the pressure of trying to fit everything into his schedule: sports, study, student association, friendships, work, and so on	0.04	16.02%	3	1	8	2	3	2	1	2
John must prioritize certain things (because of deadlines) even though personally he has other priorities he'd rather be doing	0.04	16.02%	4	4	6	0	5	1	1	1
John finds it difficult to have to meet friends. He normally likes meeting them, but now he is very busy it feels constraining	0.03	15.15%	0	4	3	6	1	5	2	1

Table 5: Results from the survey validation

As can be seen in table 5 the first seventeen stressors have a free-marginal kappa of 0.40 or higher. This means the participants mostly agreed upon the category to which these stressors belong to. Notably, every category has one or multiple stressors that have a free-marginal kappa of 0.40 or above, except for the category of Frustration. Kindness (2014) noted the same problem in his research. Frustration was a difficult category to really define and appoint stressors to. For this reason, the category of Frustration will be removed entirely for the remainder of the research. Additionally, only the stressors that marked a kappa-value of 0.40 or higher will be used in the next parts of the research. For the remainder of the stressors it is not validly clear to which category they belong, since participants did not fully agree on these.

3.3 Study 3: Personality and Stressor Combined: Therapist Interview

Now that it is clear what stressors belong to which category, the second type of information on which the algorithm bases itself needs to be introduced: personality. In this study personality and stressors will be combined and it will be tested which mindfulness exercises should be advised to these combinations. First a therapist will be interviewed to get an expert opinion. Next a survey will be held among students to determine what exercises they would advise to a certain combination of stressor and personality.

3.3.1 Method

As mentioned in subsection 2.3.5 personality is inherently connected to a person's stress coping styles. In this research the Big-five personality traits will be used to determine the personality of a student. However, because of time constraints, we are unable to test all five personality traits in combination with the stressors. According to Lee-Baggley et al. (2005) all five personality factors do influence coping styles of people. However, Neuroticism and Conscientiousness appear to be the strongest predictors of coping styles (Lee-Baggley et al., 2005; Watson and Hubbard, 1996). Watson and Hubbard (1996) concluded in their study that the trait conscientiousness is accountable for at least 29% of the variance in coping styles. This is only exceeded by the trait neuroticism, which was accountable for 40% of the variance in coping styles. Thus, neuroticism and conscientiousness are accountable for the majority (69%) of the variance in coping styles (Watson and Hubbard, 1996; Lee-Baggley et al., 2005). Because of this, it was decided to only use the personality traits of neuroticism and conscientiousness in combination with the stressors. The other three traits might be interesting for future research.

Apart from using two of the five personality traits, it also needs to be decided which stressors will ultimately be used in combination with these traits. Due to time constraints, it is not possible to test all 17 stressors, that scored a kappa value above 0.4, in combination with each personality trait. It was decided to use only the highest scoring stressor per category. In table 6 the stressors that will be used are shown.

As mentioned before, a therapist that is experienced with students and MBSR mindfulness exercises will be interviewed, whereafter a survey will be created to ask students which mindfulness exercises they would advise to a student with a certain personality in combination with a stressor. The therapist will be interviewed to get an expert opinion on which exercises they would advise and why. The interview might also help in fine tuning which mindfulness exercises are most helpful for students in general.

However, how are we going to present the combination of a certain personality and

Category	Stressor
Isolation	Because of the different courses every period, there are different people every time in lectures. That makes it really hard for John to get to know his fellow students. That makes him feel alone, even during lectures.
Physical demand	John is an intern at the hospital; he has to run around helping patients.
Mental demand	John is going through difficult study material that is very hard to understand.
Interruption	While John is studying for his exam, his mother calls.
Social-emotional demand	John feels he has to put up a nice smile and be cheerful during activities at his student association, even though he does not feel like it.
Temporal demand	John feels the time pressure of deadlines.

Table 6: Stressors that will be used in study 3

stressor to the therapist, and later to the participants of the survey? Once again, by using stories. Smith et al. (2018) have created validated stories about the Big-Five personality traits. Their stories, just like to stories about stressors, are based upon a fictional person and describe the personality trait, without actually mentioning that specific trait. For every personality trait there are two stories, since every trait has two extremes (Smith et al., 2018). For example, one story about neuroticism shows a person that possesses this trait to a lesser extent while the other story shows a person that possesses this trait to a greater extent. The same goes for stories about conscientiousness. In table 7 the four stories that will be used in this study are presented. These stories are literal copies of the stories made by Smith et al. (2018), except for names that have been changed. The names have been changed, because they each represent a different student. We chose to stick with male names, since that was also the case for the stories about the stressors.

Now that it is clear what stressors and what personality traits will be used in this study, the final variable for this study needs to be determined: the mindfulness exercises. As mentioned in sub-chapter 2.2.4 the most researched and effective mindfulness program is MBSR, created by Kabat-Zinn (2003). In this study mindfulness exercises from this program will be used. In the program, Kabat-Zinn (2003) makes a distinction between *formal* and *informal* mindfulness exercises. Formal exercises are exercises that require you to formally do an exercise and be completely devoted to the exercise. In contrast, informal exercises are practices that you can do during the day, that do not require for a person to take a formal moment out of their day to do the exercise (Kabat-Zinn, 2003). Some exercises are specifically formal or informal, while others can be done both ways.

Formal and informal exercises were taken from the MBSR program, as presented in the workbook made by Stahl and Goldstein (2010) in cooperation with Kabat-Zinn. The following exercises were taken from the book:

1. **Mindful walking meditation:** not about getting from A to B, but focusing on the walking itself. Focusing on every step, breathing and your surroundings.

2. **Mindful check-in:** a short, powerful practice that allows you to recognize how you're feeling physically, mentally, and emotionally and will help you recenter yourself in the present moment.

3. **STOP-exercise:** Useful if you feel tense or upset to check in with yourself and

Personality trait	Story
	James often feels sad and dislikes the way he is. He is often down in the dumps and suffers from frequent mood swings. He is often filled with doubts about things and is easily threatened. He gets stressed out easily, fearing the worst. He panics easily and worries about things. James is quite a nice person who tends to enjoy talking with people and tends to do his work.
	Eric seldom feels sad and is comfortable with himself. He rarely gets irritated, is not easily bothered by things and he is relaxed most of the time. He is not easily frustrated and seldom gets angry with himself. He remains calm under pressure and rarely loses his composure.
	Josh procrastinates and wastes his time. He finds it difficult to get down to work. He does just enough work to get by and often doesn't see things through, leaving them unfinished. He shirks his duties and messes things up. He doesn't put his mind on the task at hand and needs a push to get started. Josh tends to enjoy talking with people.
	Martin is always prepared. He gets tasks done right away, paying attention to detail. He makes plans and sticks to them and carries them out. He completes tasks successfully, doing things according to a plan. He is exacting in his work; he finishes what he starts. Martin is quite a nice person, tends to enjoy talking with people, and quite likes exploring new ideas.

Table 7: Personality stories

notice thoughts and the body. S = Stop, T = Take a breath, O = Observe, P = Proceed.

4. **Body Scan:** An exercise to become aware of the body and how it harbors stress and emotions. One 'scans' every part of the body separately.

5. **Sitting meditation:** becoming mindful of breathing, sensations, hearing, thoughts and emotions. Increases overall awareness of the present. Meditation can be done in either 15 minutes, 30 minutes or 45 minutes.

6. **Mindful yoga:** Doing yoga exercises. The goal is becoming aware of the body, it's movements and breathing through it.

7. **Being mindful of habits:** writing down habits to become mindful of them and whether they benefit your or not. This shows you literally the choices you have in habits.

8. **RAIN-exercise:** Specifically meant for sudden anxiety (or anxiety attack) and stress. R = recognize the strong emotion that is present. A = Allow or acknowledge that it is there. I = Investigate the body, emotions and thoughts. N = Non-identify whatever is there (understand that these strong emotions are just another passing mind state and not a definition of who you are).

9. **Loving-kindness meditation:** opening the heart to love, compassion and empathy. First bring this love and compassion to yourself. After directing love and compassion toward yourself, you extend it outward, first to those who are easy to love, such as benefactors, mentors, teachers, and others who have guided or inspired you.

10. **Mindful listening:** When someone is speaking to you, see if you can pay attention and not interrupt until the other person is completely finished speaking. Notice when your mind begins to wander off, thinking about what you need to do later that day, some grievance from the past, the brilliant counterargument that you want to make, or wherever else it may go. When this happens, just become aware of it, then intentionally bring your attention back to listening.

11. **Identify habitual patterns in current relationships:** this helps becoming aware of the way we behave in certain relationships. For example, if you notice yourself falling into victim behavior frequently with a specific person, write about how those interactions happen.

There can be other exercises that are useful as well that we have not included yet. If that is the case, we hope the therapist might provide some insight on other exercises that might be useful.

The interview will begin with an explanation of the research in general, what has been done up until now and what the goal is. Next, the therapist will have to sign an informed consent. This informed consent can be found in Appendix D. Once the therapist has consented to participate in the research, the actual interview can begin. The interview will be recorded. The personality stories and stressor stories will be printed on separate pieces of paper. Thus each story is on one piece of paper. The reason for this, is because the personality stories and stressor stories will be presented to the therapist in different combinations. For example: The story about James will be presented in combination

with the physical demand stressor. Once the therapist has given his or her advise on the combination, James will be combined with another stressor. Thus, in the end, each personality will have been paired with each stressor. The stressors will be presented in random order next to a personality, however, the personality will not be changed until it has been paired with all six stressors. To clarify: James will only be changed to Eric, once he has been paired with all six stressors, in no particular order. Next, the stressors will also be combined with Eric, and so on. This way, the therapist gets the chance to really 'get to know' the person in the story. If the personality would be switched as often as the stressors, it would be more difficult for the therapist to keep up, since they have to remember the people in the stories or reread the story again and again. That would make for a difficult and long interview, which is why we chose to only switch stressors.

Next to the personalities and stressors, will be a paper presenting the list of mindfulness exercises, as seen earlier in this chapter. The therapist will be asked to choose one of these exercises, or propose another exercise that is not on the list.

The main question in the interview will be: "this student is experiencing the presented stressful situation. What mindfulness exercise would you advise to this student, and why?".

3.3.2 Results

The interview took up around 1.5 hours. The therapist gave extensive answers for every personality and stressor, which will be very usefull in creating the survey in the next study.

First and foremost, the therapist declared that she believes it is important to state beforehand and to realize that mindfulness is a state of mind and a way of living. It is not something you should only practice when you feel stressed out. She explained the best advice she could give every student, is to follow a full 8-week course on MBSR to create this state of mind. However, she admitted that not every student might have the time or money to do that, so the idea of an adaptive application that advises mindfulness exercises would be a good start and might make more people aware of mindfulness at all. She stated that the mindfulness exercises might certainly help students in moments of stress.

With this disclaimer in mind, the interview could begin. The therapist signed the informed consent and thus the interview could be recorded. The therapist was asked to first read through the list of mindfulness exercises presented to her. She admitted to recognizing most exercises, but pointed out that some exercises had different names in Dutch. Once she was done reading, the first personality and stressor were presented to her.

Neuroticism
The first personality that was presented to her, was James, who scored high on the neuroticism scale. When first reading about James, the therapist stated, regardless of the stressor James was experiencing, that he definitely needed help. I noticed the therapist focused more on the personality type, instead of the personality in combination with a certain stressor. This was due to the fact the therapist felt he needed help, regardless of the stressor. Once I noticed this, it was decided to present both ends of the spectrum. So in case of neuroticism, I showed the therapist both James and Eric. The reason for this being that the therapist now could distinguish between personalities easier and also focus more on the stressors, instead of mostly on personality. Once this was done, the therapist

admitted the different people (James and Eric) made it easier for her to advise different exercises in combination with the stressors.

The first stressor that was then presented, was the stressor for social-emotional demand. The therapist started with a diagnosis of what was actually happening. In this case, both James and Eric are ignoring how they truly feel (they do not feel like being all smiles and happy) and thus are not accepting their true feelings. They are forcing a feeling that is not there, acting differently than they truly are. The therapist recommended to do a check-in exercise for both of them. Very important in this exercise is that it takes you off of the automated pilot (in this case still going and acting all smiles) and shows you what choices you have. The check-in makes you aware of your feelings and shows you what options you have, and that there are actually different options to choose from. Options that the therapist provided as an example in this case could be: not attending at all, attending but not acting as if everything were okay, or still attending acting happy. The last option might not coma across as a good option, but it is still an option that can be chosen. The check-in makes sure one becomes aware of their feelings and the options they have. In case of Eric, the check-in exercise might be enough to help him, since he is lower on the neurotic scale, and thus more emotionally stable. However, James needs more exercises that deepen the state of mindfulness, because he is less emotionally stable. The therapist recommended to do the check-in first, and do the 'being mindful of habits' second. The name of this second exercise was quite confusing to the therapist, since it is not only about writing down habits, but mostly about writing down thoughts. Because of this, in the remainder of the interview, the exercise was referred to as 'being mindful of habits/thoughts'. Writing down thoughts about the current situation one is experiencing, makes it easier to become aware of them and to distance oneself from them. One can ask questions about these thoughts, such as 'are these thoughts actually true?', 'are my thoughts too black and white?', 'am I only thinking negative thoughts?' and so on. By questioning ones own thoughts, one can understand them better, and perhaps learn why these thoughts are there.

The second stressor combines with Eric and James was the example of a temporal stressor. The therapist again started with a diagnosis of what was happening. In this case James and Eric are experiencing a type of stress that makes a person become quite chaotic. One loses sight of their priorities and planning becomes much harder to do. The therapist advises both Eric and James to be pulled back to the present and understand what state they are currently at, instead of only thinking of the future. To do this, the therapist advised both Eric and James to do the STOP-exercise. While explaining this exercise, the therapist notes that this exercise is essentially the same exercise as the check-in exercise. They are both short exercises about taking a moment to reflect on the current state of the mind and understanding the choices one has. Because of this, for the remainder of the interview, the check-in and STOP exercises were combined as one and will be called the 'check-in exercise'. In the case of this stressor, it made no difference if either James or Eric was experiencing it. Both were advised to do the mindful check-in to focus more on the present.

The third stressor that was combined with Eric and James, is the example for interruption. According to the therapist, when interruption occurs it is often the case one gets irritated by the interruption itself (in this case perhaps the mother that calls) and has trouble concentrating on a task again. Because of this irritation, mindful listening would be a good exercise for both Eric and James. This exercise helps them practice refocussing (as mentioned in the explanation of the exercise, bring your attention back to listening), but also helps becoming less irritated with the thing or person that has interrupted your

concentration. If one for example were to be interrupted by certain noises, one could get irritated and start focussing more and more on these noises. Mindful listening makes a person aware of the noises, yet also makes them aware they are just that: noises. The practice can eliminate the irritation that is associated with these noises, which help a person get back to the task he or she was concentrating on. Another exercise that might help these students even further, is to do a short love and kindness meditation. Due to the meditation you can process the interruption that just happened, what this interruption does to you (in the stressor about the mother that calls, this might be related to what was spoken about during the phone call) and return the attention back to yourself and your task. Both Eric and James are recommended to do either one or both of these exercises. In this case, the personality difference did not influence the advise.

The fourth stressor that was combined with Eric and James, was the example of a mental demand. The therapist noted that in case of such a demand, it can sometimes become frustrating and stressful if you cannot (immediately) solve a task, because of the mental challenge. One can develop negative thoughts about their own capabilities due to heavy mental demand. Because of this, the therapist advised the 'being mindful of habits/thoughts' exercise. In this case, the exercise would be focused on becoming mindful of mostly negative thoughts that are related to the mental demand. Another exercise that the therapist would advise is the RAIN-exercise. This exercise is similar to the check-in exercise, but more elaborate and especially meant for people having negative thoughts. The exercise focusses very much on the acceptance of certain feelings. If one is experiencing something that is mentally challenging, this exercise might help in accepting that this task is mentally challenging and that that feeling is okay. For Eric, the therapist would advise just the 'being mindful of habits/thoughts' exercise, while James would need more elaborate exercises. For James the therapist advised the 'being mindful of habits/thoughts' exercise, the RAIN exercise and potentially also the loving-kindness meditation, because James is less emotionally stable and more prone to stay in the negative thought spiral.

The fifth that was combined with Eric and James, was the example of isolation. The therapist first explained how she understood the situation. Often, when people feel alone, they jump into solving mode. The feeling of isolation needs to be solved, by for example signing up to a sports club or going to pub to drink and be around people. However, the challenge in this, is to actually sit down with this feeling and become aware of other options one has. These options often are: to act, not to act, to distract or to sit down with the feeling (this is often where a mindfulness exercise is done). In this case the therapist would advise a loving-kindness meditation to first recognize what emotions and thoughts are there, and to accept they are there. Once that is done, the student can make a conscious decision. He or she can for example decide to distract by going to the gym or reading a book. A person can also still choose to act and go to the pub to meet people. However, in this case going to the pub is a conscious decision. Some people go to the pub and drink every night, because it is their automatic pilot and they do not accept the feelings they are feeling. The meditation will help a person get off this automatic pilot, and accept the feelings they are experiencing. Personality-wise Eric would only need to do a short sitting meditation, since he is more emotionally stable and it will be easier for him to exit the feeling of isolation. James, however, is advised to do a full loving-kindness meditation, because he will doubt himself much more than Eric would.

The final stressor that was combined with Eric and James, is the example of physical demand. In this case the therapist explained that attitude towards a certain activity is very important. An activity can take up a lot of energy or give a lot of energy.

To clarify, the therapist gave the following example: cooking can take or give energy. If you are tired after work on weekdays and still need to cook, cooking might take a lot of energy. However, in the weekend, when there is lots of time to cook a meal, cooking might give a lot of energy. This is completely dependant on the attitude one has about an activity at a certain point in time. For this type of stressor, the therapist would advise to do the 'being mindful of habits/thoughts' exercise, because it shows what physical habits a person has and which of these habits might trigger stress. For this stressor, it does not matter which personality traits someone possesses. Both Eric and James can use this exercise.

Conscientiousness

Josh and Martin represent the two ends of the conscientiousness spectrum. This time both personalities were presented immediatly next to eachother to the therapist. The first stressor that was presented, was the stressor for social-emotional demand. First, just as with James and Eric, it was important for both Josh and Martin to mentally check-in with themselves and understand the options they have. Thus, both can do the mindful check-in exercise. However Josh is less stable in comparison to Martin, which is why he, just like James, needs some extra exercise. In Josh's case he needs to understand his boundaries. It could be Josh is taking up too much work and the stress makes him procrastinate instead of take some action. However, it could also be the case Josh is not mentally challenged enough, which is why he procrastinates. For both scenario's and the social-emotional stressor it is important to understand boundaries, so one can understand them. Once boundaries have been set, Josh might either want to stay under or go over these boundaries. An exercise that is very helpful in setting and understanding one's boundaries is mindful yoga. In mindful yoga you can literally feel where your boundaries are. Your body might protest or you might become impatient with the slow movements. The question in this exercise is whether you are going to cross a boundary (move beyond the pain in your body for example) or to not cross a boundary (to stop the movement). Thus in case of Josh and this stressor, he is advised to first do a check-in followed by the mindful yoga to see where his boundaries are and to decide whether he is going to cross them or not. Perhaps he discovers the boundary that he does not want to attend the event if he is not feeling like it, instead of crossing the boundary and still attending the event with a fake smile. For Martin, the check-in should be sufficient.

The second stressor that was presented in combination with Josh and Martin, was the stressor for isolation. In this case the therapist advised both Josh and Martin to do a loving-kindness meditation to recognize what emotions are there, to accept them, be kind to oneself and to see the different options they have. This type of personality trait did not influence the advise that was given for this type of stressor as much, as neuroticism does.

The third stressor that was presented in combination with Josh and Martin, was the example of a temporal demand. In this case the conscientiousness personality trait did matter, since this stressor is very much related to procrastination and planning. In Martin's case, the therapist argued he is probably quite a perfectionist and very much up in his head, especially with temporal demands. It would be important for him to take a break sometimes and get out of his head. To do that, he is advised to do the body-scan exercise, which leads attention away from your brain towards your body. As for Josh, he is advised to do the 'being mindful of habits/thoughts'-exercise to become aware of the thoughts and the (bad) habits he has.

The fourth stressor that was presented, was the example of mental demand.

Since Martin is quite a perfectionist, he will probably keep on going until he understands a difficult problem. He would need to learn to accept not being able to understand everything and he would not be a failure if he does not understand something. Because of this, the therapist recommends the loving-kindness meditation for Martin. Another exercise she would recommend to Martin is the 'being mindful of habits/thoughts' so he becomes aware of his perfectionist thoughts.

3.4 Study 4: Questioning Students

The initial plan was to interview a few therapists on this topic. However, many therapists were either too busy to make time in their schedule or not knowledgeable enough on the topic of mindfulness to be able to provide steady advice on the topic.

For this reason, and because the interviewed therapist already gave extensive advise, it was decided to question students on the same topic. They are, after all, the audience the algorithm will be tailored to.

3.4.1 Method

The method for questioning students was quite similar to the interview questions for the therapist. Students would have to fill out a survey, which contained combinations of stressors and personality, where they had to choose which exercise they would advise a fellow student in certain situations. It was only possible to choose one exercise per question.

The survey starts off with an introduction to the survey (see Appendix E). The next page of the survey contains explanations on all mindfulness exercises the participants can choose from (see Appendix F. This way, participants will have already read through the exercises at least once, which might help them fill out the survey quicker and easier.

The following pages contained the actual survey questions. In Appendix G an example of a survey question is displayed. First a personality story is displayed, after which the stressful situation follows. Every question is the same: *What mindfulness exercise would you advice [person] in this situation?*. The mindfulness exercises are displayed underneath this question, supplemented with short explanations.

two surveys were created, which only differed in personality: one for neuroticism and one for conscientiousness. In both surveys the participants would first get six questions which contained the personality stories on the low end of the personality spectrum, followed by six questions containing stories on the high end of the spectrum. It was decided to not randomly arrange the questions, but ask six questions about the same personality in a row, because it would be less confusing for the participants and they were able to focus on just one personality trait per six stressors.

3.4.2 Results

Both surveys were filled out by 20 students, which makes 40 participants in total. Surveyswap.io was used to distribute the survey. Surveyswap is a website specifically meant for distributing and filling out surveys. When distributing, one can choose specific filters for a survey. For these surveys we choose only students between the ages of 18 and 30 were to fill out the surveys. The reason for this age group being in The Netherlands 18 is considered as the official age of adulthood, while 30 is considered to be the latest age one can still study using governmental financial support.

A MANOVA was performed on the data, since there were two groups of participants and multiple variables that are dependent and independent. In this case the variables 'Stressor' and 'Personality' were independent variables, while the variable 'Exercise' was the dependent variable, considering this is what students had to choose from in the surveys. In Tables 8 and 9 the results of the MANOVA are summarized. Only significant results ($p < 0.05$) are displayed in these tables. Per exercise is shown whether there is a significant correlation with stressor, personality and stressor x personality.

From the results one can tell there seems to be no significant correlation between exercises and stressor x personality. It appears stressor was of most influence on the decision for a certain exercise for both neuroticism and conscientiousness. However, the MANOVA analyses the variables as a whole and does not tell us exactly what exercises were significantly more chosen for which stressor, or combination of stressor x personality. For this reason, it was decided to perform the Tukey Post-hoc test to get an insight on were exactly the differences lie in the data. The Tukey Post-hoc test compares all possible pairs of means and finds out which specific groups means (when compared to each other) are significantly different.

Tables 10 and 11 show the results of the Post-Hoc test. If there are two or more subsets for one combination of exercise and stressor, or exercise and stressor x personality, it means there is a significant difference between which exercises were chosen the most and which were chosen the least. If there are two or more subsets that means in every subset there are some stressors that are exclusive to that subset and some stressors that are also present in the other subset.The exclusive stressors in each subset is what we are interested in. In the tables the exclusive stressors are marked with a '*'. The mean in the tables is always between 0 and 1, because these values were used in SPSS to indicate whether and exercise was chosen (1) or not (0). If a cell in the table says 'no effect' it means there was only one set and no two subsets or more, which means there is no significant difference.

For example in Table 10, the exercise Check-in seems to be significantly more chosen for a Temporal demand stressor in comparison to other stressors (the mean is higher). Another example: in Table 11 the exercise Mindful Listening seems to be significantly more chosen for the stressor 'Interruption' in comparison to other stressors.

To summarize the results of Tables 10 and 11:
Table 10: in this table we primarily looked at the column 'Stressors in subset' since most significant differences were found there and the other columns show either 'no effect' or the same result.

1. The exercise Check-in was significantly advised more for the stressor Temporal demand in comparison to other stressors.

2. The exercise Body Scan showed no significant difference in use for certain stressors and/or high or low conscientiousness.

3. The exercise Yoga showed no significant difference in use for certain stressors and/or high or low conscientiousness.

4. The exercise of Being Mindful of Habits/thoughts was significantly advised more for the stressor Mental demand in comparison to other stressors.

5. The exercise RAIN showed no significant difference in use for certain stressors and/or high or low conscientiousness.

6. The exercise Loving-kindness meditation was significantly advised more for the stressor Loneliness/Isolation in comparison to other stressors.

7. The exercise Mindful Listening was significantly advised more for the stressor Interruption in comparison to other stressors.

Table 11: in this table we also primarily looked at the column 'Stressors in subset' since most significant differences were found there and the other columns show either 'no effect' or the same result.

1. The exercise Check-in was significantly advised more for the stressor Temporal demand in comparison to other stressors.

2. The exercise Body Scan was significantly advised more for the stressor Physical demand in comparison to other stressors.

3. The exercise Yoga was significantly advised more for the stressor Mental demand in comparison to other stressors.

4. The exercise Check-in was significantly advised more for the stressor Social-Emotional demand in comparison to other stressors.

5. The exercise RAIN showed no significant difference in use for certain stressors and/or high or low conscientiousness.

6. The exercise Loving-kindness meditation was significantly advised more for the stressor Loneliness/Isolation in comparison to other stressors.

7. The exercise Mindful Listening was significantly advised more for the stressor Interruption in comparison to other stressors.

	Stressor	Conscientiousness	Stressor x Conscientiousness
CI	$F(5) = 2.661$, p <0.05	$F(1) = 4.219$, p <0.05	-
BS	-	-	-
Y	-	-	-
HT	$F(5) = 4.567$, p <0.01	-	-
R	-	-	-
LK	$F(5) = 4.748$, p <0.01	-	-
ML	$F(5) = 5.953$, p <0.01	-	-

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, R = RAIN, LK = Loving-Kindness meditation, ML = Mindful Listening.

Table 8: Exercises vs. stressors and conscientiousness

	Stressor	Neuroticism	Stressor x Neuroticism
CI	F(5) = 3.999, p <0.01	-	-
BS	F(5) = 3.238, p <0.01	-	-
Y	F(5) = 3.040, p <0.05	-	-
HT	F(5) = 2.515, p <0.05	-	-
R	-	-	-
LK	F(5) = 8.297, p <0.01	-	-
ML	F(5) = 6.455, p <0.01	-	-

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, R = RAIN, LK = Loving-Kindness meditation, ML = Mindful Listening.

Table 9: Exercises vs. stressors and neuroticism

	Effect of stressor		Effect of Conscientiousness x stressor			
			High		Low	
Exercise	Stressors in subset	Mean	Stressors in subset	Mean	Stressors in Subset	Mean
CI	Lo*, Phy, Me, In, So-Em	0.20	no effect		no effect	
	Phy, Me, In, So-Em, Te*	0.27				
BS	no effect		no effect		no effect	
Y	no effect		no effect		no effect	
HT	Phy*, In, So-Em, Te	0.06	no effect		Phy*, In, So-Em, Lo, Te	0.09
	In, So-Em, Te, Lo*	0.11			In, So-Em, Lo, Te, Me*	0.15
	Te, Lo, Me*	0.20				
R	no effect		no effect		no effect	
LK	Te*, Me*, Phy, In, So-Em	0.14	no effect		Te*, Me*, In, Phy, So-Em	0.11
	Phy, In, So-Em, Lo*	0.25			In, Phy, So-Em, Lo*	0.23
ML	Me*, Te*, So-Em*, Lo*, Phy	0.09	Me*, Te*, So-Em*, Lo, Phy	0.10	Te*, Me*, Lo, Phy, So-Em	0.08
	Phy, In*	0.25	Lo, Phy, In*	0.27	Lo, Phy, So-Em, In*	0.18

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, R = RAIN, LK = Loving-Kindness meditation, ML = Mindful Listening.

Note: Me = Mental demand, Lo = Loneliness, So-Em = Social-Emotional demand, In = interruption, Phy = Physical demand, Te = Temporal demand

Table 10: Results of Tukey Post-Hoc test for Conscientiousness

| | Effect of stressor | | Effect of Neuroticism x stressor | | | |
| | | | High | | Low | |
Exercise	Stressors in subset	Mean	Stressors in subset	Mean	Stressors in Subset	Mean
CI	Me*, Lo*, So-Em*, In, Phy	0.22	no effect		Me*, Lo*, So-Em, Phy, In	0.19
	In, Phy, Te*	0.38			So-Em, Phy, In, Te*	0.33
BS	In*, Lo, So-Em, Te, Me	0.07	no effect		no effect	
	Lo, So-Em, Te, Me, Phy*	0.69				
Y	In*, Lo*, So-Em, Te, Phy	0.08	no effect		no effect	
	So-Em, Te, Phy, Me*	0.15				
HT	Phy*, In, Te, Me, Lo	0.10	no effect		no effect	
	In, Te, Me, Lo, So-Em*	0.14				
R	no effect		no effect		no effect	
LK	Te*, Me, Phy, In	0.12	Te*, Me, So-Em, Phy, In	0.19	Te*, Me*, In*, Phy*, So-Em	0.09
	Me, Phy, In, So-Em*	0.18	Me, So-Em, Phy, In, Lo*	0.28	So-Em, Lo*	0.40
	Lo*	0.50				
ML	Te, So-Em, Me, Lo, Phy	0.08	Te*, Lo, Phy, So-Em, Me	0.05	Te*, Me*, So-Em*, Lo*, Phy	0.08
	In*	0.35	Lo, Phy, So-Em, Me, In*	0.11	Phy, In*	0.28

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, R = RAIN, LK = Loving-Kindness meditation, ML = Mindful Listening.

Note: Me = Mental demand, Lo = Loneliness, So-Em = Social-Emotional demand, In = interruption, Phy = Physical demand, Te = Temporal demand

Table 11: Results of Tukey Post-Hoc test for Neuroticism

3.5 Study 5: Designing The Algorithm

In this final study the algorithm is designed, based upon all previous studies that were done.

3.5.1 The algorithm

Advise and knowledge was gathered from two types of human sources: the therapist and the students. From the results the students produced, we can see not all stressors were advised one exercise significantly more than other exercises. Because of this, it was decided to use all significant exercises in the algorithm, and supplement this with the exercises the therapist advised. Sometimes the advised exercises by the students and therapist are the same, while sometimes they differ. Tables 12 and 13 give an overview of the exercises that were advised by the therapist and the students.

Stressor	Low Neuroticism		High Neuroticism	
	Therapist	*Students*	*Therapist*	*Students*
Soc-Emo	* CI	* HT	* CI	* HT
			* HT	
Temp	* CI	* CI	* CI	* CI
Inter	* ML	* ML	* ML	* ML
	* LK		* LK	
Mental	* HT	*Y	* HT	* Y
			* RAIN	
			* LK	
Lone	* CI	* LK	* LK	* LK
Physic	* HT	* BS	* HT	* BS

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, LK = Loving-Kindness meditation, ML = Mindful Listening.

Table 12: A comparison of the exercises that were advised by students and the therapist

Stressor	Low Conscientiousness		High Conscientiousness	
	Therapist	*Students*	*Therapist*	*Students*
Soc-Emo	* CI	-	* CI	* HT
	* Y			
Temp	* HT	* CI	* BS	* CI
Inter	* ML	* ML	* ML	* ML
	* LK		* LK	
Mental	* HT	* HT	* HT	* HT
			* LK	
Lone	* LK	* LK	* LK	* LK
Physic	* HT	-	* HT	-

Note: CI = Check-in, BS = Body Scan, Y = Yoga, HT = Being mindful of habits and thoughts, LK = Loving-Kindness meditation, ML = Mindful Listening.

Table 13: A comparison of the exercises that were advised by students and the therapist

Based upon these results the following algorithm was designed:

```
s = stressor type
n = neuroticism level
c = conscientiousness level
    if s = Soc-Emo AND n = high OR n = low AND c = high {
        Advise(Check-in);
        Advise(Habits/thoughts);
    }
    else if s = Soc-Emo AND n = high OR n = low AND c = low {
        Advise(Check-in);
        Advise(Habits/thoughts);
        Advise(Yoga);
    }
    else if s = Temp AND n = high OR n = low AND c = high {
        Advise(Check-in);
        Advise(BodyScan);
    }
    else if s = Temp AND n = high OR n = low AND c = low {
        Advise(Check-in);
        Advise(Habits/thoughts);
    }
    else if s = Inter {
        Advise(MindfulListening);
        Advise(LovingKindness);
    }
    else if s = Mental AND n = high AND c = high OR c = low {
        Advise(Habits/thoughts);
        Advise(RAIN);
        Advise(LovingKindness)
        Advise(Yoga)
    }
    else if s = Mental AND n = low AND c = high {
        Advise(Habits/thoughts);
        Advise(Yoga);
        Advise(LovingKindness);
    }
    else if s = Mental AND n = low AND c = low {
        Advise(Habits/thoughts);
        Advise(Yoga);
    }
    else if s = Lone AND n = high AND c = high OR c = low {
        Advise(LovingKindness);
    }
    else if s = Lone AND n = low AND c = high OR c = low {
        Advise(LovingKindness);
        Advise(Check-in);
    }
    else if s = Physic {
        Advise(Habits/thoughts);
```

```
        Advise(BodyScan);
    }
```

3.6 Study 6: Testing the perceived effectiveness

Once the algorithm is designed it is supposed to be tested. Due to the time constraints of this thesis, only the perceived effectiveness will be tested among students. This means students will give their opinion on the exercises the algorithm presents to them.

3.6.1 Method

To test the perceived effectiveness among students two different surveys were used. Once again, one survey for the Neuroticism personality trait, and one for Conscientiousness. The setup of the surveys was quite identical to the surveys used in Study 5. Students were presented with a combination of a personality story and a stressor. The question asked, however, was different: "The algorithm advises the following two exercises. Rank in the sliders below how effective you think each exercise would be, based on the stressful situation and personality of the student." Below this question one or more exercises are presented to the student. These are the exercises the algorithm would advise to the combination of stressor and personality. The participants than have to rate the exercises on a scale from 1 (not effective) to 8 (very effective). We purposely chose for an even-numbered likert scale, so participants would be unable to chose an inbetween option.

3.6.2 Results

40 participants filled out the surveys, 20 participants each survey. The surveys were, once again, distributed via Surveyswap.io. In the filtering criteria presented by Surveyswap, the filter 'only students' was chosen, to fill out these surveys. After all, the goal of these surveys is to collect the opinions of students on the possible effectiveness of the algorithm.

Once the results were collected, datasheets were made in SPSS. In the survey participants had to answer on an 8-point likert scale. If participants chose a five or higher, it is interpreted as perceived as effective. If participants chose a 4 or lower, it is interpreted as perceived as not effective. A one-sample one-tailed T-test was performed on the data using a comparison value of 4.5, which is the exact middle of our 8-point likert scale. One-tailed was chosen, because we want to know whether students significantly chose higher or lower than 4.5.

Tables 14 and 15 show the results that followed from this one-sample T-test. If a cell in the column 'p-value' has a value that says 'no effect', it means the p-value was higher than 0.05, and thus not significant. We are primarily interested in the exercises that were perceived as possibly effective, which is why the last column in each table showcases how much percent of the participants chose 'effective'.

Table 14 summarized:
The combination of the stressor 'Social-Emotional demand', high neuroticism and the exercises HT and CI are perceived as possibly significantly effective. One can see the percentages that chose effective are quite high as well. In comparison, low neuroticism in this combination shows these exercises were not perceived as effective. Study 5 showed there was no significant effect of personality on the choice of exercise for these combinations. However, the results of this study show there might be a difference between the two personality levels. Perhaps this should be tested again in the future using more participants,

to understand whether there is an influence of personality in this specific combination or not.

The combinations of 'Temporal demand', high and low neuroticism, and the exercise CI are all perceived as possibly significantly effective. Participants appear to agree with the advise the algorithm has given in these cases.

In case of the stressor 'Interruption' the only combination that is perceived as significantly effective, is the combination of high neuroticism and the exercise ML. In study 5 the exercise ML was advised by the therapist as well as advised by students. This result shows there might be a difference between personality level and exercise on this combination. However, since it was tested among a small sample of 20 students, a higher sample might show more clear and significant numbers.

Mental demand shows no significant perceived effectiveness on any exercise in any level of neuroticism. The percentages of participants choosing for effective are also quite near the 50 percent for all exercises in this combination. Perhaps participants feel mindfulness might not be the right type of help when experiencing such a stressor. However, this is a hypothesis that could to be tested in future research, perhaps by interviewing students about this particular stressor in combination with mindfulness.

As for the stressor 'Loneliness/Isolation', the exercise LK is deemed as good advise by the algorithm, since in both neuroticism levels it is significantly perceived as effective. The exercise CI shows no significant effect. A reason for this might be that the exercise is a lot more widely applicable (in many different situations) and less focused on building a relationship of love with oneself. Loneliness can make a person feel less confident about oneself, which the exercise LK is mainly focused on.

The stressor 'Physical Demand' has only one exercise that is significantly perceived as effective, which is BS combined with a high level of neuroticism. BS is also advised for the low level of neuroticism, but in this case is not seen as significantly perceived effective. However, the percentage of people choosing effective for this combination is quite high: 70%. Because of this trend, in future research one could redo this part of the survey with more participants, to see if the reason for this result is the sample size or whether participants still not perceive the exercise as effective in this combination. The exercise HT not perceived as effective in both high and low neuroticism levels.

Table 15 summarized:
The combination of the stressor 'Social-Emotional Demand', conscientiousness (both high and low), and the exercise CI are significantly perceived as effective by the participants, thus they agree on the advise the algorithm gives. The exercise Y in combination with low conscientiousness is not significantly perceived as effective.

The stressor 'Temporal Demand' in combination with conscientiousness shows significantly perceived as effective for the exercises CI (high and low) and HT (only low). Only the exercise BS is not seen as possibly effective. BS is a very much bodily focused exercise, while CI and HT are very much focused on the mind. For temporal demands participants thus seem to prefer mind-focused exercises in this case.

In case of the stressor 'Interruption' the only combination that is significantly perceived as effective, is the combination of high conscientiousness and the exercise KL. This result is a bit similar to the result for neuroticism on this combination, except the exercise differs. Perhaps some completely different mindfulness exercises could be tested on the low-personality-level-interruption combination (for conscientiousness as well as for neuroticism), since ML and KL are not perceived as effective. Another explanation might be that mindfulness exercises might not be the right help for this combination to help

Stressor	Neuroticism	Exercise	Mean (Std.)	p-value	% that chose effective
Soc-Emo	*High*	HT	5.85 (1.42)	p <0.01	80
		CI	5.55 (1.57)	p <0.01	75
	Low	HT	4.70 (1.78)	no effect	60
		CI	5.00 (1.59)	no effect	60
Temp	*High*	CI	5.40 (1.31)	p <0.01	80
	Low	CI	5.15 (1.63)	p <0.05	70
Inter	*High*	ML	5.30 (1.56)	p <0.05	70
		LK	4.95 (1.67)	no effect	65
	Low	ML	4.15 (1.69)	no effect	50
		LK	4.70 (1.75)	no effect	55
Mental	*High*	Y	4.80 (1.96)	no effect	55
		HT	4.90 (1.29)	no effect	60
		LK	4.50 (2.21)	no effect	50
	Low	BS	4.35 (1.73)	no effect	55
		Y	4.90 (1.94)	no effect	60
		HT	4.55 (1.67)	no effect	60
Lone	*High*	LK	5.65 (1.31)	p <0.01	80
	Low	LK	5.50 (1.76)	p <0.05	75
		CI	4.95 (1.43)	no effect	65
Physic	*High*	BS	5.15 (1.63)	p <0.05	65
		HT	4.85 (1.76)	no effect	65
	Low	BS	5.00 (1.75)	no effect	70
		HT	4.50 (1.50)	no effect	50

Table 14: Overview of T-test results for Neuroticism

regulate emotions. This can be tested in future research.

As for the stressor 'Mental Demand' the only combination that is significantly perceived as effective is the combination of high conscientiousness and the exercise HT. However, for low conscientiousness, the exercise HT is not perceived as effective. The exercise LK appears to not be perceived as effective for both high and low conscientiousness.

The stressor 'Loneliness/Isolation' was advised the exercise LK for both high and low conscientiousness. However, only for high conscientiousness the exercise is significantly perceived as effective. Perhaps a difference in personality trait does matter in this case.

Finally, the stressor 'Physical Demand' in combination with high and low conscientiousness, and the exercise HT, shows for both personality-traits this exercise is significantly perceived as effective.

Stressor	Conscientiousness	Exercise	Mean (Std.)	p-value	% that chose effective
Soc-Emo	*High*	CI	6.33 (1.46)	p <0.01	94.4
	Low	CI	6.22 (1.31)	p <0.01	88.9
		Y	4.61 (2.03)	no effect	66.7
Temp	*High*	CI	6.44 (1.34)	p <0.01	94.4
		BS	5.17 (1.82)	no effect	61.1
	Low	CI	5.44 (1.54)	p <0.01	77.8
		HT	5.61 (1.91)	p <0.05	83.3
Inter	*High*	ML	4.72 (2.14)	no effect	55.6
		LK	5.28 (1.67)	p <0.05	72.2
	Low	LK	4.94 (2.13)	no effect	61.1
		ML	5.06 (2.01)	no effect	61.1
Mental	*High*	HT	5.61 (1.98)	p <0.05	72.2
		LK	4.33 (1.91)	no effect	66.7
	Low	HT	4.28 (1.81)	no effect	50
		LK	3.89 (1.71)	no effect	44.4
Lone	*High*	LK	5.72 (1.97)	p <0.01	83.3
	Low	LK	4.89 (2.19)	no effect	66.7
Physic	*High*	HT	5.39 (1.61)	p <0.05	72.2
	Low	HT	5.56 (1.54)	p <0.01	72.2

Table 15: Overview of T-test results for Conscientiousness

3.7 Conclusion

The goal of this thesis was to explore the possibilities for a digital intervention that helps students regulate their emotions, using mindfulness exercises. The end product of this thesis is an algorithm, produced using the exploration done in this thesis. The main question of this research was: *"What effective adaptive digital behavior intervention can we design, for supporting students to improve their ability to regulate emotions?"* To answer this question, some sub-questions were composed. They will be answered here.

3.7.1 What stressors do students experience and how can these be portrayed?

The literature has shown us there are many different stressors students experience, that can be, but do not have to be, specific for students. Examples are: change in sleeping habits, change in eating habits, new responsibilities, increased workload, financial difficulties, change in social activities (Ross et al., 1999). Most stressors seem to be focused on the many changes a student goes through in this new phase in life. However the literature also pointed out one can also focus on specific groups of students, such as international students or students with a specific major (Robotham and Julian, 2006; Radcliffe and Lester, 2003; Peluso et al., 2011). These students experience some specific stressors that other students might not.

Because this thesis is focused on Dutch students, it was important to understand what stressors Dutch students experience. To understand this, focus groups with Dutch students were performed. 60 stressors were collected. Some were similar to stressors collected in previous researches (such as the examples that were presented earlier), while others were very much related to only Dutch students, such as frustration on economic cuts that hit students and help raise a study debt.To get a full overview of all stressors collected see Table 4.

The portrayel of these stressors is important for the future parts of the research, since they were used in many different study's. First the stressors where divided into categories, since the algorithm will at first need some sort of category indication of different stressors to be able to recommend an exercise. The stressors were categorized into seven categories, inspired by Kindness (2014). Kindness (2014) also worked with stressors in his research and portrayed them using stories. This method was tested and validated by him, and thus also used in this research to portray stressors. An example of such a story would be: "John notices his friends seem to be much closer to each other than they are to him". Hereafter, the categorization of the stressors was validated, using a survey asking participants to choose a category to which they think each stressor belongs. The category of Frustration was deleted, since participants could not agree on what stressors belong in this category. The categories left are: Physical Demand, Mental Demand, Social-emotional Demand, Temporal demand, Loneliness/Isolation, and Interruption.

3.7.2 What emotion regulation techniques exist?

According to the literature there are six different types of emotion regulation techniques: reappraisal, suppression, avoidance, rumination, problem-solving, and acceptance (Gross, 1998; Aldao et al., 2010). In this research, we focused on an acceptance technique: mindfulness. Mindfulness is "the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment" (Kabat-Zinn, 2003). Mindfulness has become quite a popular technique to use to regulate emotions. It has proven many times it's positive effect on depression and

coping with stress.

3.7.3 What are already existing digital interventions for emotion regulation?

There are some digital interventions that are focused on emotion regulation. As the literature has shown, examples of such interventions are the app-suite IntelliCare by Mohr et al. (2017) or the game-based intervention SPARKX by Merry et al. (2012). All these interventions are meant for emotion regulation, but miss the one aspect we are most interested in in this research: the ability to advise emotion regulation techniques in an adaptive manner.

3.7.4 How do people adapt the selection of emotion regulation techniques to the characteristics of the person and the stressors experienced?

To answer this research question, two study's were performed to get two different viewpoints. In the first study (Study 4) an expert (a therapist) was interviewed about this topic. Next to stressor, personality can also be of big influence on the way we regulate our emotions. Especially neuroticism and conscientiousness of the big-five personality traits are of influence. The expert was presented with combinations of a stressor and a personality (high- or low-leveled in neuroticism or conscientiousness). Next to this a list of mindfulness exercises was presented. She was asked to advise the personalities in combination with the stressors some minfulness exercises. The main conclusions from this interview were that highly neurotic people probably need to do more than one mindfulness exercise, or a more in depth exercise. For low neurotic people one more simple exercise should be sufficient. As for conscientiousness, there is not such a typical difference in her advise between high and low conscientiousness. However, there were sometimes differences that were noticable. High was mostly advised to try and take a step back, so mostly bodily exercises to get out of his/her head would fit best. Low conscientiousness was mostly advised to analyse habits and try his/her boundaries.

In the second study (Study 5) the viewpoint of students was asked, since they will be the public the algorithm is directed to. Students received a survey that asked the same question as was asked of the therapist. However, they only got to choose one exercise to advise to a combination of stressor and personality. From these surveys the results were collected and it appeared most students focused more on the stressor than the personality. Some combinations of stressor and personality showed significant results, but most significant results were found when looking at stressor alone.

In many cases the students and therapist agreed on the exercises that they would advise, for example for the stressor Loneliness, the exercise Loving-Kindness meditation was often advised by both parties, regardless of the personality. Same goes for the exercise of Mindful Listening that was mostly advised to people experiencing the stressor Interruption. However, in case of a Physical demand, the therapist and students advised completely different exercises. The therapist chose for the more mind-related exercise of Being mindful of habits/thoughts, while the students chose for the more bodily-related exercise that is the Body Scan. Especially for these types of results, it was important to test the perceived effectiveness of the exercises that would be advised by the algorithm to students. Perhaps one exercise was perceived as effective, while the other is not, or they might both be perceived as effective (or not).

3.7.5 What algorithm can mimick these adaptations?

From the previous research done in Study 4 and Study 5, an algorithm was created. The full algorithm can be found in Section 3.5.1. All exercises that were advised by the expert, and all exercises that were significantly more advised by the students are used in the algorithm. This produces and algorithm that provides at minimum one to maximum 4 exercises to each combination of stressor and personality-level. The next step was to test the perceived effectiveness among students.

3.7.6 What is the perceived effectiveness of the resulting behavior intervention?

To answer this question, in study 7, two surveys where done among students. One survey regarding neuroticism and one survey regarding conscientiousness. Students were shown combinations of stressors and personality, and the exercises the algorithm would advise to these combinations. Students than had to choose how effective they think and exercise would be in for a combination. These surveys showed whether students think the advise is good and agree with the algorithm.

Some results showed students might perceive the effectiveness of an exercise differently for a certain personality level. For example: the combinations of the stressor Social-Emotional demand, neuroticism, and the exercises Being Mindful of Habits/Thoughts and the Check-in show a difference in results between high and low neuroticism. For high neuroticism, these exercises are perceived as effective, while for low neuroticism they do not.

Other results show students think an advised exercise would work for both personality levels. For example: for the combinations of the stressor Social-Emotional demand, conscientiousness, and the exercise Check-in show students perceive this exercise as effective for both high and low conscientiousness. In this case the personality does not seem to be of great influence.

Finally, there are also results where full combinations of a stressor, both personality-levels and all exercises show no significant agreement at all. For example: for the stressor Mental Demand combined with neuroticism, no exercise is significantly perceived as effective. One can ask if this means mindfulness might not be the right way to regulate emotions for these combinations, or perhaps the 'right' exercise was just not included in the algorithm.

3.7.7 Final conclusions

Now the sub-questions are answered, the main research question of this thesis can be attempted to answer. The question is: "What effective adaptive digital behavior intervention can we design, for supporting students to improve their ability to regulate emotions?".

The intervention that was designed is an adaptive algorithm that is based off of the human advise an expert and fellow students would give, to students in need of help with emotion regulation. The algorithm is adaptive, because it adapts it's advise to the type of stressor and the personality-traits the student in need provides to the algorithm. The algorithm gives advise through the recommendation of mindfulness exercises, based upon combinations of stressor and personality. Due to time constraints on this research, only the perceived effectiveness was tested among students, which showed for some advise the students agreed with the algorithm, while some advise was not significantly perceived as effective. This research delivers a first concept algorithm (or digital intervention) that

can be tested and perfected in future researches. It can be implemented in different ways (in a chat-bot, as a question-answer application and so on).

3.8 Discussion

In this discussion some limitations of this research and ideas for future research are presented.

3.8.1 Limitations

The first limitation of this research is that the number of participants that took part in the surveys was quite small. Each survey was filled out by at least 20 participants. That makes a total of 120 participants for all surveys. 20 participants is often the minimum that is necessary for a statistical test. Due to time constraints on the thesis, and the search for participants for 6 surveys, it was decided to take at least the minimum to be able to perform statistical tests on the results. Perhaps performing these surveys again with more participants might present different results or perhaps strengthen current results.

Another limitation of this research is the fact that only the perceived effectiveness was tested. This does unfortunately tell us nothing of the actual effectiveness of the algorithm. However, it was a conscious decision not to test the algorithm's actual effectiveness. If one wants to test the effectiveness of the algorithm, there are many different ways to do this. For example: the algorithm can be implemented in an app and tested among users. However, how does one implement the algorithm? Will be app be in the form of a question-answer or will it for example be a chat-bot? Another way of testing the algorithm's advise is to use the Wizard-Of-Oz method, in which a human mimics the algorithm's intelligence and interacts with the user through a computer interface (Green and Wei-Haas, 1985). There are many more methods to test an algorithm. However, one method might provide a more positive result in comparison to another method. That is why it would be best to test the algorithm in different methods and situations so one gets a good overview of it's effectiveness. That is, due to time constraints, not possible in this research.

A third limitation of this research is the fact that we did not succeed in interviewing multiple experts on what exercises they would advise to the combinations of stressor and personality. We did get the expert-opinion of one therapist, however, it was the initial plan to gather multiple viewpoints. This was solved by surveying the students the algorithm is geared towards. However, more expert opinions might either strengthen the advise given by the expert in this research, or perhaps provide some new insights on what exercises to advise students and why.

Another limitation is regarding the questioning of students on what exercise they would advise their fellow students (study 5). It was chosen to perform surveys among students, to gather information on what they would advise. However, in these surveys students could only choose one exercise to advise to a student. This decision was made to keep the number of exercises advised to a particular combination in the algorithm to a minimum. However, this might have increased the difficulty of filling out this survey a bit, since the students can only choose one option. Perhaps, for future research, students can be given the option of selecting multiple exercises, or the option to provide a reasoning for choosing a certain exercise.

3.8.2 Recommendations for future research

In future research the limitations of this research could be taken into account. The surveys can be performed again, but it is recommended to use a lot more participants to be able to perform many different statistical tests on the results. Of course, the actual effectiveness can be tested in future research, using different methods that were already mentioned in the previous section on limitations. Only by testing the algorithms actual effect, can it be adjusted and perfected, and perhaps implemented.

Another idea for future research is to interview experts (therapists) on the advise the algorithm provides and see their opinion on this. Do they agree with the advise the algorithm provides? If so, why? If not, why not? These experts can provide some new insights and perhaps help adjust the algorithm for the better.

If the algorithm is to implemented in an application, another important factor to perform future research on is the design of this application. The design of the application might enhance or decrease the effectiveness of the implemented algorithm. What is the best application design for the algorithm that was designed in this research?

Finally, it might also be important to find out whether Mindfulness exercises are actually applicable and/or effective for all the stressors mentioned in this research. As seen in the results of Study 7, for the stressor mental demand and the personality neuroticism there was no exercise that was perceived as effective. Perhaps Mindfulness is not the right choice for this combination. Another explanation might be that the 'right' exercise is not yet found for this combination. For these types of results, more research is required on the effectiveness of mindfulness exercises on certain stressors.

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Appendices

A   Study 1: Information sheet and informed consent

Age:..........

What gender do you identify with most? (circle your preference)
Male /Female /Other /Prefer not to say

Study:..

Information about the research:

It has become apparent in the last few years how much students struggle with stress, burn-outs and mental health issues. The need for help has become significantly higher.
We want to create a computer-based application that can help students cope with stressful situations.
Before we can create such an application, we need to know what stresses students out in their daily lives. In this focus group I would like to know what stresses you out and why? With your permission, I would like to record the audio of the discussions, so I can easily listen to the discussion again. After I have written down the results of the focus group, the recorded audio will be deleted.
If there are any questions or complaints, you can always contact me or my supervisor.

My contact information is:
Name: Frederique Janssens
e-mail address: f.g.h.janssens@uu.nl

My supervisor's contact information is:
Name: Judith Masthoff
e-mail address: j.f.m.masthoff@uu.nl

Informed consent

I hereby declare that I was informed well about the reasoning and method of this research. I take part in this research on a completely voluntary basis. It is my right to revoke this consent at any time, without specifying a reason for this. I am fully aware that I can leave the focus group at any moment.
If my results should be used in any scientific publication, or be made public in any other way, they should be fully anonymized. My personal information or audio recording will not be shared with third parties, without my permission.
If I want any more information or have complaints about this research, I can contact Frederique Janssens or Judith Masthoff.

I declare to understand everything that is written above and agree to partake in this research:

Date:......................   **Signature:**.........................

B   Study 2: Converted stressors

Category	Stressors
Mental demands	
	• John has the feeling he is not good enough academically, and thus trying hard to better himself.
	• John has the feeling he is not good enough personally, and thus trying hard to better himself.
	• John is about to take an exam; he normally experiences anxiety shortly before and during exams that makes him feel sick, which makes it very hard to focus.
	• John is trying to keep up with his personal time schedule.
	• The whole concept of studying is challenging for John: going to lectures, self-study at home, the need for a social life and such.
	• John must focus on less interesting assignments.
	• John is doing an internship in a hospital, and must be prepared for lessons and patients that are coming up.
	• John is going through difficult study material that is hard to understand.
	• John feels the pressure of other people expecting him to do well.
	• Finding a job is challenging for John: searching for vacancies, writing motivation letters and so on.
	• John feels pressure to do many different things and be the best at these things during his studies, to be able to obtain a good job.

Physical demands	
	• John feels the societal pressure of being slim and skinny.
	• John is feeling sick but still must go to work or lectures, because he needs to be able to pay for everything and get good grades.
	• John must find the correct room in which the exam takes place in time.
	• Due to bad time management, John must cycle really fast to his part-time job.
	• Cycling to the train station is stressful because John is late.
	• John has one lecture in the morning and one lecture in the evening on the same day, meaning he must cycle four times as he does not like to stay at uni all day.
	• John is ill, but he does not have the time to be ill and get better, because there are tasks he has to do.
	• John must go to uni, but it is raining very heavily.
	• John is an intern at the hospital; he is has to run around helping patients.

Social-Emotional demands	
	• John feels like he can't open up 100% to certain people and that is stressful.
	• John had a fight with his girlfriend before class. Now he must act normal among his fellow students, while he does not feel happy.
	• John fears missing out, because he cannot join his friends in the bar.
	• John finds groupwork very stressful, because there are conflicts with his teammates.
	• John has a hard time trying to communicate with his grandmother who is suffering from dementia.
	• John feels working together with other students in his team challenging.
	• John has to give a presentation. He finds presenting in front of the class quite challenging, because everybody is looking at him and he feels the pressure to present well and be interesting.
	• John feels he has to put up a nice smile and be cheerful during activities at his student-association, even though he does not feel like it.
	• John finds it difficult to have to meet friends. He normally likes meeting them, but now he is very busy it feels constraining.
	• John feels it is expected of him to be happy and interested even though he is not.
	• John feels he must be 'involved' with friends and always make conversation with them.
	• John is doing an internship in a hospital and feels he must be nice to a patient, even though they just treated him badly.

Frustration	
	- John received a bad grade, while he was expecting a good one.
	- John must take the bus during rush hour; there are delays and the bus is very crowded.
	- John's assessors have different ideas of how the assignment should be assessed, which confuses him.
	- The train John takes every day to get to university is delayed.
	- John is aware that economic cuts hit students and teachers. He has attended many protest marches on this issue, but nothing has happened as a result.
	- John must study too much subject matter.
	- John has a high study debt.
	- While John is studying in the University Library, some students keep getting up and making noise.
	- Customers in the restaurant John works at sometimes forget what they ordered and expect him to know it.
	- A customer at the restaurant in which John works has been very rude to him.
Temporal demands	
	- John feels the time pressure of deadlines.
	- John feels the pressure of trying to fit everything into his schedule: sports, study, student association, friendships, work, and so on.
	- Today John has lectures during mid-day; he feels there is no useful time left before or after the lectures.
	- John feels the time pressure of studying for exams.
	- John feels the time pressure of being on time for a friend's wedding ceremony.
	- John feels the time pressure of having to read many articles in a very short period of time.

Isolation / Loneliness	
	• John is studying in the Netherlands. He would like to speak Dutch, but since he does not, sometimes he feels excluded from his fellow students.
	• John thinks he feels more pressure because of his studies than other students feel, making him feel like he is the only one.
	• Because of the different courses every period, there are different people every time in lectures. That makes it really hard for John to get to know his fellow students. That makes him feel alone, even during lectures.
	• John notices his friends seem to be much closer to each other than they are to him.
	• Fellow students have made plans without John.
	• John is home alone.
	• John has the feeling he has to put in a lot of effort to belong to a group of people.
Interruption	
	• John is following a lecture, but some students are chatting during the lecture.
	• John is following a lecture, but some students are doing completely different things on their computers during the lecture, which are distracting him.
	• While John is studying for his exam, his mother calls.
	• While John is studying for his exam, he receives a notice from Netflix about new episodes of his favorite show.
	• John must prioritize certain things (because of deadlines) even though personally he has other priorities he'd rather be doing.

C   Study 2: Survey instructions

Dear sir/madam,

Thank you for participating in this survey! Please read the instructions carefully.

We want to create a digital application that can support students when they feel stressed out. We have asked students what type of stressors they experience in their daily lives. Stressors are things or situations that stimulate a feeling of stress.

There are 7 types of stressors:

1. **Physical demand:** any physical activity that is demanded of a person, that can become a stressor. For example, if one has to cycle to work, while it is very slippery outside.

2. **Mental demand:** any kind of mental activity that demands a lot of thinking.

3. **Temporal demand:** any kind of time-related demand. For example, time-pressure.

4. **Social-Emotional demand:** any kind of emotion that is demanded in a certain situation. For example, a nurse has to show sympathy towards her patients, even if they are not always kind to her.

5. **Frustration:** the feeling of frustration or annoyance that happens due to an activity. For example, planning to visit a specific restaurant, which turns out to be closed.

6. **Isolation/Loneliness:** the feeling of being alone and isolated from other people.

7. **Interruption:** when interruption is causing stress during an activity. For example, when concentrating hard on a task, someone interrupts your concentration when they start talking to you.

We have collected several stressors students experience. We want you to decide which stressor belongs to which category. If a stressor does not belong to any category, or it is not clear for you to which category it belongs, you can always choose 'Other'.

Remember, there is no right or wrong! Everything you choose is fine.

By filling out this survey, you agree that we anonymously use your data for our research. This data will be deleted as soon as it is not needed anymore to calculate results.
If there are any questions, you can send me an e-mail at: f.g.h.janssens@uu.nl

D   Study 3: Informed consent Therapist

Informed consent

I hereby declare that I was informed well about the reasoning and method of this research. I take part in this research on a completely voluntary basis. It is my right to revoke this consent at any time, without specifying a reason for this. I am fully aware that this interview is recorded and I can stop this interview at any time.
If my results should be used in any scientific publication, or be made public in any other way, they should be fully anonymized. My personal information or audio recording will not be shared with third parties, without my permission.
If I want any more information or have complaints about this research, I can contact Frederique Janssens or Judith Masthoff.

I declare to understand everything that is written above and agree to partake in this research:

Date:.....................   **Signature:**.........................

E   Study 4: Information before the survey

Dear sir/madam,

Thank you for participating in this survey! We want to help students cope with stress better, through the use of mindfulness exercises. We want to design an application that can advise the right mindfulness exercises at the right time. To be able to design an application that can do this, we want to know what mindfulness exercises humans would advise to students in certain situations.

In this survey students with certain personality traits are presented to you. These students are experiencing some situations that are stressful to them. Next, to the question, a list of mindfulness exercises will be presented.

You choose which mindfulness exercise you would advise a student in a certain situation.

Remember, there is no right or wrong! We want to know your opinion.

By participating in this survey, you agree that your results will be, anonymously, used in this research. The results will be saved no longer than is needed to analyze them. If there are any questions, you can send me an e-mail at: f.g.h.janssens@uu.nl

F Information on the exercises

Please read through the following mindfulness exercises. You do not have to remember them, but the survey will be easier and faster once you've read through them once.

1. **Mindful check-in**: a short exercise that allows you to recognize how you're feeling physically, mentally, and emotionally and will help you re-center yourself in the present moment. You stop, take a breath, recognize your feelings and decide what options you have.

2. **Body scan**: an exercise to become aware of the body and how it harbors stress and emotions. One 'scans' every part of the body separately. This reverts the attention from the mind to something else: the body.

3. **Mindful yoga:** doing yoga exercises mindfully. It helps becoming aware of the body, it's movements and breathing through it. The goal is to recognize boundaries one may (or may not) have (mentally and physically) and whether to respect them or break them.

4. **Being mindful of habits/thoughts**: Writing down thoughts/habits, makes it easier to become aware of them and to distance oneself from them. One can ask questions about them, such as 'are these thoughts actually true?', 'are my thoughts too black and white?', 'does this habit benefit me or not?'.

5. **RAIN-exercise**: Specifically meant for sudden anxiety. R = recognize the strong emotion that is present. A = Allow or acknowledge that it is there. I = Investigate the body, emotions and thoughts. N = Non-identify whatever is there (understand that these strong emotions are just another passing mind state and not a definition of who you are)

6. **Loving and kindness meditation:** opening the heart to love, compassion and empathy. First bring this love and compassion to yourself, before you can extend it towards others.

7. **Mindful listening:** mindful listening can be done two ways: one is listening to someone telling a story and notices how the mind wanders off and pulls it back to attention. Another way is to mindfully listen to noises that at first annoy you. This exercise will change your attitude towards the noises that they are just that: noises.

G   Study 4: Example question

Universiteit Utrecht

Meet James:
James often feels sad and dislikes the way he is. He is often down in the dumps and suffers from frequent mood swings. He is often filled with doubts about things and is easily threatened. He gets stressed out easily, fearing the worst. He panics easily and worries about things. James is quite a nice person who tends to enjoy talking with people and tends to do his work.

James is experiencing the following stressful situation/feeling:
James feels he has to put up a nice smile and be cheerful during activities at his student association, even though he does not feel like it.

What mindfulness exercise would you advise James in this situation?

Mindful check-in: a short exercise that allows you to recognize how you're feeling physically, mentally, and emotionally and will help you re-center yourself in the present moment. You stop, take a breath, recognize your feelings and decide what options you have.

Body scan: an exercise to become aware of the body and how it harbors stress and emotions. One 'scans' every part of the body separately. This reverts the attention from the mind to something else: the body.

Mindful yoga: doing yoga exercises mindfully. It helps becoming aware of the body, it's movements and breathing through it. The goal is to recognize boundaries one may (or may not) have (mentally and physically) and whether to respect them or break them.

Being mindful of habits/thoughts: Writing down thoughts/habits, makes it easier to become aware of them and to distance oneself from them. One can ask questions about them, such as 'are these thoughts actually true?', 'are my thoughts too black and white?', 'does this habit benefit me or not?'.

RAIN-exercise: Specifically meant for sudden anxiety. R = recognize the strong emotion that is present. A = Allow or acknowledge that it is there. I = Investigate the body, emotions and thoughts. N = Non-identify whatever is there (understand that these strong emotions are just another passing mind state and not a definition of who you are)

Loving and kindness meditation: opening the heart to love, compassion and empathy. First bring this love and compassion to yourself, before you can extend it towards others.

Mindful listening: mindful listening can be done two ways: one is listening to someone telling a story and notices how the mind wanders off and pulls it back to attention. Another way is to mindfully listen to noises that at first annoy you. This exercise will change your attitude towards the noises that they are just that: noises.