Requirements for Relaxation Coaching
A Formalization of the Fogg Behavior Model

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Abstract: Relaxation training consists of doing regular (e.g., daily) relaxation exercises over a longer period of time (e.g., months). Adherence to relaxation training is for many people difficult because of time constraints, social obligations, forgetting to practice and so on. This is a pity because relaxation training can act as a natural antidote to health-related effects of excessive stress like poor sleep. In this paper, we present a formal model of relaxation coaching that is rooted in the theory of persuasive design. This model supports the development of coaching systems that can improve people's adherence to relaxation training with its associated health benefits.

1 THE NEED FOR RELAXATION

Ben is a fifty year old teacher of mathematics at a secondary school. He suffers from a lot of stress in his life. Each day he has deadlines that he cannot finish and so he spends most of his evenings marking assignments and exams. When lying in bed he feels wide awake, worrying about tomorrow and unable to fall asleep. When he gets up in the mornings he feels exhausted.

In today's society, many people have problems related to excessive stress, like poor sleep (American Psychological Association, 2014). Excessive stress and poor sleep have negative effects on people's health and well-being (Everly Jr. and Lating, 2013). Excessive stress is known to accelerate the aging process (Liu and Mori, 1999). Poor sleep is a prevalent problem for the elderly (Kamel and Gammack, 2006).

Ben visits his general practitioner who prescribes him relaxation training. In eight weekly sessions with a therapist, Ben practices relaxation and starts to feel better. He finds himself spending less time lying awake in bed and he feels more refreshed in the mornings.

Relaxation training is a mind-body intervention that counteracts the harmful effects of stress (Dusek and Benson, 2009). It has been shown helpful for aging people (Galvin et al., 2006; Glei et al., 2012). Relaxation training is an integral part of insomnia therapy (Morin and Espie, 2004) and has been shown helpful for elder people with poor sleep (Friedman et al., 1989; Sun et al., 2013).

After the eighth and last training session, Ben receives from his therapist a transcript of the relaxation exercise to practice at home on a regular basis. Although Ben is motivated the first couple of days, he starts to skip doing the exercise more and more and eventually stops practicing altogether. A few weeks later he sleeps as badly and feels as stressed as before.

Traditional relaxation training is provided through individual or group sessions supervised by a therapist (Everly Jr. and Lating, 2013). Usually, these sessions are supplemented with home-practice assignments (Bernstein et al., 2000). Adherence to relaxation training is difficult (Taylor et al., 1983; Jacob et al., 1984) due to for instance time constraints, social obligations and simply forgetting to practice (Murdoch, 2000).

Ben installs a mobile coaching application. The system assists Ben in understanding the workings and effects of the relaxation exercises, modifying exercises to his specific needs and circumstances and in actually performing the exercises. With the use of the coaching system Ben starts to practice relaxation on a regular basis at home. He regains the benefits from his improved relaxation skills, like less stress and better sleep.

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Mobile coaching systems have the potential to improve therapy adherence by providing additional support (Klein et al., 2013). This holds also for insomnia therapy (Espie et al., 2013). The elderly form a diverse group with a variety of characteristics (Gregor et al., 2002), which requires the tailoring of support to specific needs and circumstances .

In this paper, we address the problem of developing coaching systems to improve adherence to relaxation training by providing tailored support. The main contribution of the paper is the development of *the basic requirements for relaxation coaching in the form of a formal model that is rooted in the theory of persuasive design* (Section 3). In Section 2 we provide background on relaxation training and persuasive design. In section 4 we provide conclusions and outlines for further research.

2 RELAXATION & PERSUASION

The stress response is an activation of the sympathetic nervous system which due to the mediation of stress-related hormones like cortisol and epinephrine leads to physiological phenomena like an increase of oxygen consumption, blood pressure and heart rate. In this way, the body is prepared for taking action. Excessive invocation of the stress response can lead to many kinds of health issues and diseases (Everly Jr. and Lating, 2013).

The relaxation response is the exact opposite of the stress response (Benson, 1993): the sympathetic nervous system is de-activiated leading to among others a decrease in oxygen consumption, blood pressure and heart rate. In this manner, the body works towards rest and recovery. The relaxation response can act as a natural antidote to the stress response, undoing (parts of) its harmful effects. Whereas the stress response occurs involuntary and automatically, the relaxation response needs to be consciously invoked and requires repeated practice in the form of relaxation exercises. Many types of relaxation exercises exist. Prominent types are (mindfulness) meditation, progressive muscle relaxation and yoga.

Building new behavior like doing relaxation exercises on a regular basis at home can be supported by technology (Oinas-Kukkonen, 2012). Such supporting technology is usually referred to as *persuasive technology* (Fogg, 2003). Persuasive technology aims at changing people's behavior and / or attitudes in a non-forceful way without using non-ethical means such as deception. The design of persuasive technology is not an easy task and attempts are easy to fail.

Different models of human behavior are used in the development of persuasive technology (Mohr et al., 2014). Relaxation exercises are a relatively simple and well-defined type of behavior. To understand the persuasive aspects of such behavior, the Fogg behavior model can be used (Mohr et al., 2014). According to the Fogg behavior model (Fogg, 2009), for particular behavior to occur three factors have to come together: A person should (i) be motivated to do the behavior, (ii) have the ability to perform the behavior and (iii) the behavior should be triggered. If one of (i), (ii) and (iii) is not met, the behavior will not occur.

3 COACHING ALGORITHM

In his paper, Fogg provides a qualitative description of his behavior model (Fogg, 2009). However, for a coaching system to support behavior change and be able to reason about the different components of behavior we need a (simple) formal model. This model is presented in Table 1.

Motivation. Fogg defines three dimensions of motivation: 'pleasure and pain', 'hope and fear' and 'social acceptance and rejection'. We will consider each of these in the light of relaxation training.

First, a person's motivation depends on the emotions and sensations of pleasure and pain that he or she experiences in the here and now. In the context of relaxation training this dimension can be operationalized as the state of relaxation and/or stress a person experiences and the immediate effects exercises have on this state.

The relaxation effects of exercises depend on the type of exercise and the type of person. Some breathing exercises have almost immediate calming effects like for instance 'ocean breathing'. This is a technique from yoga in which the practitioner slows down his or her breath by a muscle contraction in the throat. A few minutes of ocean breathing in bed can induce a profound state of relaxation. Additionally, different people prefer different types of relaxation exercises.

A way to measure relaxation is in terms of so-called subjective units of relaxation (SURS) (Everly Jr. and Lating, 2013). On this scale, a score of 10 corresponds to a dreamlike state of profound relaxation, while a score of 5 corresponds to the state of an average person on an average day. A score of 1 corresponds to a panic attack (Everly Jr. and Lating, 2013). For instance, if a person feels very stressed (e.g., has a SURS of 3) and wants to feel better than average (e.g., SURS of 6) and ocean breathing results in an increase of 1 unit per 5 minutes practicing, then the person is motivated to do up to 15 minutes of ocean breathing.

Table 1: Components of Relaxation Coaching

	Fogg behavior model	**Relaxation training**	**Units**
Motivation	Pleasure	Relaxation state	SURS
	Hope	Sleep quality	sleep hours / bed hours
	Social acceptance	Social status	social levels
Ability	Time	Duration	minutes
	Money	Price	euro's
	Non-routine	Skill progression	skill levels
	Physical effort	Energy	kJ / hour · kg
	Brain-cycles	Information	words / minute
	Social deviation	Privacy deviation	privacy levels
Triggering	Spark	Education	motivation
	Facilitator	Modification	ability
	Signal	Instruction	performance levels

Secondly, 'hope and fear' constitutes the dimension of thoughts and feelings about future states of being. In the context of relaxation training this can be operationalized as the anticipated longer-term effects of relaxation training, like better sleep. In insomnia therapy, relaxation exercises are performed on a regular basis (e.g., once or twice daily) for weeks or months (Morin and Espie, 2004). Different measurements of quality of sleep exist (Buysse et al., 1989), a prominent one being 'sleep efficiency'. This measure amounts to the time a person has slept divided by the total time the person has spent in bed. For instance, if a person has practiced a daily progressive muscle relaxation for three weeks, which led to an improvement in sleep efficiency from 0.5 to 0.6, and he wants to improve his sleep efficiency to 0.7 then he will be motivated to practice the daily relaxation exercise for another three weeks (assuming a linear relation between duration of practice and sleep efficiency).

Finally, 'social acceptance and rejection' concerns the social dimension of motivation. We can operationalize it as social status, which is a combination of education, profession, marital status and sex (Hollingshead, 1975). In the context of relaxation training, we can take this to be the combination of received relaxation training (e.g., education in the form of a completed 8-week mindfulness training, a 500 hour yoga teacher training and so on) and provided relaxation training (e.g., 3 years experience as a professional yoga teacher). We can quantify this as a social level between 1 and 10 (e.g., 1 denotes the level of a beginner student and 10 denotes the level of an expert teacher). For instance, a person who has practiced mindfulness meditation for four years (e.g., level 4) and wants to progress one level is motivated to do a mindfulness teacher training program (e.g., yielding a social status of level 5).

Ability. The ability to do a relaxation exercise depends on the resources one has available to practice. According to the Fogg behavior model, ability can be decomposed into the availability of six different resources: time, money, non-routine, physical effort, brain cycles and social deviance.

We start with the time it takes to perform a behavior. In the context of relaxation training, the ability to do a relaxation exercise depends on the duration of the exercise and the time one has available to practice. For instance, if a person is able to spend 5 minutes of practice and the practice consists of an exercise with a duration of 3 minutes then the person has the ability to do it. On the other hand, if for the same person under the same circumstances the practice would consist of a 7 minute exercise, the person would be unable to do it.

Secondly, we consider 'money': the monetary costs that are associated with the behavior. Different exercises have different costs associated with them. There are many relaxation exercises freely available on the Internet. Other exercises are described in books or on DVD's that the practitioner must buy to get access. Yet other exercises are learned under supervision of a relaxation therapist, which are even more expensive. So for instance, if a person is not able to spend any money on a relaxation practice, then he will be able to do freely available exercises, but not ones that are supervised by a therapist.

Let us consider 'non-routine'. A routine behavior is a behavior that people are used to do, possi-

bly over and over again. A non-routine behavior on the other hand, is a behavior that people are not used to do and maybe have never done before. We can operationalize the resource 'non-routine' in terms of skill levels, quantified by natural numbers between 0 and *max_skill*. Relaxation training programs involve a progression through skill levels. For instance, different yoga techniques are assigned different skill levels leading practitioners to progress from one level to a next (Iyengar, 1966). So for instance, an absolute beginner (level 1) who has no ability to progress yet has the ability to do a yoga posture like mountain pose (level 1) but is unable to do a headstand (level 4) (Iyengar, 1966).

Next, we consider the resource 'physical effort'. Different relaxation exercises require different amounts of physical effort. For instance, mindfulness-based stress reduction contains both seated and walking meditation exercises (Kabat-Zinn, 1990). A walking exercise requires more physical effort than a sitting exercise (Montoye, 2008). The resource 'physical effort' can be operationalized in terms of energy expenditure, quantified by natural numbers between 0 and *max_energy*. Usually, this is expressed in kilojoules per hour per kilogram bodyweight, although other alternative measures exist (Montoye, 2008). Walking takes $3,5$ times more energy than sitting (i.e., $3,5$ and $1,0$ $kJ \cdot h^{-1} \cdot kg^{-1}$, respectively). So for instance, a person who is able to spend $2,0$ $kJ \cdot h^{-1} \cdot kg^{-1}$ has with respect to the resource 'physical effort' the ability to practice a sitting meditation, but is not able to do a walking practice.

Next comes the resource 'brain cycles'. According to Fogg, this concerns the thinking process that is involved in performing the behavior. Some relaxation exercises require only a few instructions to perform. An example is a breath awareness exercise in which a practitioner is simply asked to concentrate on his or her breath and when attention waivers to notice the source of distraction and then bring the attention back to the breath (Kabat-Zinn, 1990). Other relaxation exercises involve many more instructions, like for instance progressive muscle relaxation in which the practitioner is required to tense and release specific muscles in specific ways in specific orderings (Bernstein et al., 2000). We operationalize the resource 'brain cycles' as the information to be processed in order to perform the behavior. This can operationalized as information processing speed (Kail and Salthouse, 1994). In the context of relaxation training, we can quantify this as the number of words of the instruction per minute. For instance, a person who is not able to process more than 30 words per minute is able to do a breath awareness exercise with an instruction of 20 words per minute, while being unable to do a progressive muscle relaxation exercise involving an instruction of 60 words per minute.

Finally, we consider the resource 'social deviance'. According to Fogg this amounts to going against the norms of a social context. Some relaxation exercises require more privacy than others. For instance, progressive muscle relaxation should be done in a quiet environment with no distractions. It requires the practitioner to sit down and close his or her eyes. Some informal mindfulness exercises on the other hand, require the practitioner just to be aware of sensations and thoughts and should be done in the midst of hectic everyday life. We operationalize 'social deviance' as the difference between achieved privacy and desired privacy (Altman, 1976). It can be quantified in terms of levels of privacy, ranging from 0 to *max_privacy*. Achieved privacy corresponds to the level of privacy of the actual context, while desired privacy corresponds to the level of privacy that is theoretically required for the exercise. So for instance, if a person is in a business environment (e.g., achieved privacy level 1) and he is able to deviate one level of privacy, he is able to do an informal mindfulness exercise (e.g., desired privacy level 2), but not able to do a progressive muscle relaxation (e.g., desired privacy level 5).

Triggering. According to Fogg, a trigger is something that tells people to do a behavior. There are three types of triggers: sparks, facilitators and signals.

A spark is used to increase a person's motivation for the behavior. We operationalize this as the education that comes with relaxation training, explaining among others the rationale, workings and effects of the exercises. Manuals for relaxation training like the manuals of mindfulness based stress reduction (Kabat-Zinn, 1990) and progressive muscle relaxation (Bernstein et al., 2000) contain a lot of educational material. For instance, education on the nature of stress (e.g., the harmful effects of the stress response) and relaxation (e.g., the need to repeatedly invoke the relaxation response as an antidote to excessive stress) and their effects on sleep (e.g., it is easier to sleep with a calm mind than an overactive one) can increase a person's motivation for doing relaxation exercises. Education can be measured in terms of the effects it has on a person's motivation. For instance, by informing a person about the effects of having done a daily progressive muscle relaxation exercise for three weeks (i.e., an improvement in sleep efficiency from 0.5 to 0.6), the person becomes motivated to do the practice for another three weeks.

A facilitator is used to increase a person's ability

to do the behavior. We operationalize this as the modification of exercises to a person's needs and circumstances. For instance, the tailoring of exercises to the individual is an important aspect of yoga (Desikachar, 2010). Modification can be measured in terms of its effects on the ability of a person to do the exercise. For instance, if for a meditation exercise the instruction to walk (which requires $3,5\ kJ \cdot h^{-1} \cdot kg^{-1}$) is modified to an instruction to stay seated (requiring $1,0\ kJ \cdot h^{-1} \cdot kg^{-1}$), then a person who can spend $1,0\ kJ \cdot h^{-1} \cdot kg^{-1}$ gains the ability to do the exercise.

Finally, a signal is used to let a person actually perform the behavior. We operationalize it as the instruction that is needed to perform the exercise. Exercise can have different instructions. For instance, the instruction of an exercise can vary from just mentioning the name of the exercise ('do 15 minutes of body scan now') to a detailed, step-by-step guidance through the exercise ('... now bring your attention to your feet ...'). Performance can be measured as a number between 0 and *max_performance*. For instance, for a person who does not know the body scan exercise, the instruction 'do 15 minutes of body scan now' does not lead to the performance of the exercise (e.g., performance level 0), while a step-by-step guidance through the exercise results in an actual performance of the exercise (e.g., level 1).

Algorithm. Finally, we take the described components together in a basic algorithm of relaxation coaching. Figure 1 depicts the pseudo code of the algorithm.

The algorithm takes as input a relaxation training program *trp*, which is modeled as a list of exercises. In each round of the algorithm, the next exercise of the list (i.e., $head(trp)$) is selected. The coach assesses the person's motivation with respect to this exercise and while the person is not motivated to do the exercise, the coach intervenes through education. After that an assessment of the person's abilities is made and the coach modifies the exercise to fit it to the person's circumstances. Finally, an assessment of the performance is made: While the exercise has not been performed, the coach provides instruction to do the exercise. In the last step of the algorithm, the performed exercise is removed from the training program, yielding $tail(trp)$ and the new exercise to be performed is selected. The algorithm terminates when there are no more exercises to be done (that is, *e* equals *NIL*).

Related Work. Stress@work is a system for stress coaching that monitors people's stress at work and gives recommendations how to handle it (Bakker et al., 2012). The system encompasses an algorithm for stress intervention that involves the recommendation of relaxation exercises. This model is not clearly rooted in the theory of persuasive design.

```
COACH(rtp:relaxation_training_program)
   e:exercise;
   m:motivation;
   a:ability;
   p:performance;
   e=head(rtp);
   WHILE e!=NIL do;
      WHILE NOT motivated(m,e) do
         m=educate(m,e);
      END-WHILE
      WHILE NOT able(a,e) do
         a=modify(a,e);
      END-WHILE
      WHILE NOT performed(p,e) do
         p=instruct(p,e);
      END-WHILE
      trp=tail(trp);
      e=head(trp);
   END-WHILE
```

Figure 1: The coaching algorithm.

A model of exercise support in the context of insomnia therapy is provided by Beun and colleagues (Beun et al., 2014). This model identifies exercises support as a cyclic process consisting of four stages of exercise support: introduction, plan and commit, task execution and evaluation. No further details on the application to relaxation exercises are provided.

4 CONCLUSIONS

We have developed basic requirements for relaxation coaching in the form of a formal model that is rooted in the theory of persuasive design.

The model is to be considered as a first step to be further refined and extended with other operationalizations and measures. To mention one example, the resource 'physical effort' can be extended with a measure for physical impairments (e.g., incapability to stand or walk, a shoulder injury and so on).

Next steps of the requirement engineering process are the design, prototyping and evaluation of mobile relaxation coaching systems, which should provide further feedback to improve the formal model.

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