A Formal Model of Coaching Progressive Relaxation

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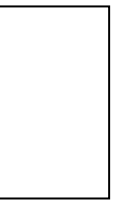

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ABSTRACT
In this paper, we address the issue how a computing system can coach people in doing progressive muscle relaxation exercises. Such a system could help many people in dealing with their stress-related problems like poor sleep. We develop a formal model of progressive muscle relaxation, provide examples of typical instantiations of the model and identify how different coaching activities have their effects on the model. The model can be used as a basis on top of which concrete coaching applications can be developed.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Training, user-oriented design I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems

General Terms
Design, Human Factors, Languages,

Keywords
Coaching, stress, physical exercises, relaxation, formal model, algorithm

1. INTRODUCTION
Nowadays, many people suffer from stress-related problems like poor sleep. Relaxation exercises can help people to deal with stress. Through books, DVDs and the web people have direct access to a plethora of relaxation exercises. However, many people have difficulties in choosing appropriate exercises, to actually do them and to keep practicing regularly.

In this paper, we address the issue how a computing system can coach people in doing relaxation exercises.

We focus on a family of well-established relaxation exercises called Progressive Muscle Relaxation (PMR) (Jacobson, 1938).

The contribution of this paper is threefold:

1. a basic structure of progressive muscle relaxation is formalized with the aim to capture the essence of what this relaxation technique amounts to
2. some examples of typical instantiations of the formal model are given indicating both the generality of the model as well as the diversity of the covered exercises
3. a number of coaching tasks is identified and it is discussed how these affect the variables of the formal model

With these contributions we lay an abstract foundation for understanding the coaching of relaxation on top of which concrete computing systems (e.g., software applications for the desktop, mobile phone) can be developed.

2. PROGRESSIVE RELAXATION
In a progressive muscle relaxation exercise the practitioner tenses a particular body part and then subsequently releases the tension paying particular attention to the feelings of tension and relaxation and noticing the differences between the two. Figure 1 depicts a typical fragment of a PMR exercise script.

```
... Right hand and forearm: Tense your
right hand and forearm by making a fist
with your right hand. Hold the tension for
5 seconds. Focus on the tension in your
hand and your arm below the elbow. Relax
your hand and arm by opening the hands,
releasing the tension for about 10
seconds. Notice the difference between the
tension and the relaxation. Right upper
arm: Tense your right upper arm by
bringing it up to your shoulder ...
```

Figure 1. A typical fragment of a PMR exercise.

After working on a particular body part the same cycle of tensing and releasing is applied to a next body part. This procedure is repeated until all (major) areas of the body have been covered.

There exist many different PMR exercises, since there are many different PMR coaches, each having their own view on what a good PMR exercise amounts to. It is not our aim here to opt for a specific exercise program but to capture the essence of progressive muscle relaxation and to identify its many variations.

3. A FORMAL MODEL
In this section we develop a formal model of progressive muscle relaxation. It will consist of a model for cycles, exercises and programs.

3.1 Cycles
We start with modeling the basic PMR cycle which consists of tensing and releasing a specific body part. Figure 2 depicts the basic algorithm in pseudo code.

```
PMR_cycle(body_part b, instruction i)
b.tense(i.how_to1)
b.keep_tension(time1)
```

```
b.feel_tension(i.what_to1)


b.release(i.how_to2)
b.keep_release(time2)
b.feel_release(i.what_to2)
```

Figure 2. The basic PMR cycle of tensing and releasing a body part.

In this algorithm *b* denotes the specific body part that is being addressed. It is modeled as an object with a number of methods associated with it. These are methods for tensing / releasing, keeping the tension / release and feeling the tension / release. The arguments *time1* and *time2* denote the time to hold the tension and the release, respectively. Typically, these are constant throughout the entire PMR exercise. The arguments *i.how_to1* and *i.how_to2* are instructions how to tense / release the body part (e.g., "tense your hand by making a fist"). The arguments *i.what_to1* and *i.what_to2* denote directions on what to feel during tensing / releasing. All these instructions are grouped together into an instruction object *i*, which together with the body part *b* form the parameters of the algorithm.

3.2 Exercises

Next, we consider a complete PMR exercise, which consists of performing PMR cycles on various parts of the body. A typical sequence is to start at the hands, then work up to the head and then all the way down to the feet visiting all the major muscle groups of the body.

A PMR cycle is typically performed twice on each body part. The instructions in these subsequent cycles might differ. Typically, in the second cycle some instructions are left out ("tense your hand" vs. "tense your hand by making a fist"). Figure 3 depicts the basic steps of the algorithm.

```
PMR_exercise(body_parts bs,
             instructions is)
    for each b in bs
    for k=1 to repetitions
    do PMR_cycle(b,is.get(b,k))
```

Figure 3. Basic steps of a PMR exercise.

In this algorithm *bs* denotes the sequence of body parts that are visited in the exercise. On each of these body parts one or more tensing and releasing cycles are performed. The variable *repetitions* denotes the number of cycles per body part. This is typically constant during the entire PMR exercise. The parameter *is* denotes an object that contains instructions for how to tense and release body parts and what to feel when tensing and releasing them. It has a method *get(b,k)* that yields the specific instructions in performing a PMR cycle on the body part *b* for the *k*-th (first, second ...) time.

3.3 Programs

Relaxation is something that is not learned overnight. PMR exercises need to be practiced over a longer period of time typically spanning several weeks and done a number of times a day (e.g., one practice in the morning and one in the evening). As the practitioner progresses (e.g., from a beginner level to intermediate to advanced) the instructions typically start to involve more refined aspects of the movements and sensations ("feel the contraction of your bicep" vs. "feel the tension in your arm"). Additionally, a program typically consists of full practices (all body parts), abbreviated practices (selection of body parts) and practices to break the routine (differently ordered sequences). The algorithm is depicted in Figure 4.

```
PMR_program
for each t in schedule
do PMR_exercise(body_parts_seqs.get(t),
instructs_with_refinements.get(level))
```

Figure 4: The basics of a PMR program

In this algorithm schedule denotes a sequence of time points at which a PMR exercise is performed. The object *body_parts_seqs* groups together all body part sequences (full, abbreviated, different orderings) of the program. It has a method *get(t)* that yields the particular sequence of body parts that is visited during the PMR exercise at time point *t*. The object *instructs_with_refinements* groups together all instructions with their refinements (ranging from coarse to fine-grained). It has a method *get(level)* where *level* denotes the current level of the practitioner that yields the instructions for the PMR exercise at the appropriate level of refinement.

4. COACHING OF RELAXATION

The coaching of progressive muscle relaxation amounts to a number of related activities. (1) A coach assesses the personal needs and circumstances of the practitioner (e.g., prior experience, injuries, time available). (2) The coach designs a PMR program tailored to the specific needs and circumstances of the practitioner. (3) The coach guides the practitioner through the program making adjustments where needed along the way.

4.1 Assessment

Each practitioner has its own unique needs and circumstances. Some practitioners have plenty of time available to do exercises while others only have a few spare minutes a day to practice. One of the goals of the assessment is to find the time available to the practitioner on the basis of which appropriate values for the variables *time1* and *time2* (used in **PMR_cycle**), *repetitions* (used in **PMR_exercise**) and *schedule* (used in **PMR_schedule**) can be set.

Secondly, some practitioners have injuries in specific body parts (like sore shoulders) while others are completely free of pain. An injured body area needs to recover and not be subject to tension and release cycles. The coach needs to find the injured areas in the practitioner's body, which then will be omitted from the object *body_parts_seqs* (used in **PMR_program**).

Finally, some practitioners are used to attend to bodily sensations while for others this is completely new territory. The coach needs to assess the prior experience of the practitioner on the basis of which an appropriate instance for the variable *level* (used in **PMR_program**) can be chosen.

4.2 Design

The goal of the design activity is to find in collaboration with a human coach an appropriate instance of the object *instructs_with_refinements* (used in **PMR_program**). Some coaches like to use verbose language ("now please try, when you are ready, to bring your shoulders all the way up to your ears in such a manner that they can almost touch them"), while others prefer to use plain language ("bring your shoulders to your ears").

A second goal is to select in collaboration with a human coach an appropriate instance of the object *body_parts_seqs* (used in **PMR_program**). Some coaches prefer to start the exercise at the hands and finish at the feet, while others for instance prefer to start at the feet and finish at the head.

4.3 Guidance

Guidance is a very intricate activity involving many different aspects, like for instance the scheduling of practice sessions (involving the variable *schedule* in **PMR_program**) as well as their rescheduling (e.g., when the practitioner has forgotten or is not able to practice a scheduled exercise). Other aspects of guidance are reminding the practitioner when sessions are due, presenting the exercise (e.g., using audio and / or video) and monitoring the execution of exercises (including their (longer term) effects). The variables involved in the reminding, presenting and monitoring activities are not part of the formal model yet and need to be explored in future research.

5. RELATED WORK

Computer systems that coach people to deal with stress constitute a relatively new area of research. Systems are beginning to emerge that measure user stress and give recommendations to the user how to deal with it. (cf. Bakker et al., 2012). A number of guidelines have been developed prescribing how these systems should present themselves to the user (in their interface) such that they have a calming rather than an arousing effect (Moraveji and Soesanto, 2012). In the system described in (Hudlicka, 2011) an embodied conversational character is used in the interface to guide a practitioner through a relaxation program based on mindfulness meditation.

6. CONCLUSIONS AND DISCUSSION

In this paper, we addressed the question how computers can be used to coach relaxation. For this we developed a formal model of progressive muscle relaxation. We have given examples of typical instantiations of this model showing its generality and the diversity of PMR exercises. We also considered the coaching tasks of assessment, design and guidance and their effects on the variables of the formal model.

The material presented in this paper is a first step in developing a formal model of coaching relaxation. Many aspects need to be worked out in future research. The algorithms for the assessment, design and guidance activities need to be developed. Progressive muscle relaxation can be combined with other types of relaxation exercises (see (Smith et al., 1996) for an overview of types of relaxation exercises), including breathing exercises (e.g., exhaling when releasing, diaphragmatic breathing), autogenic training (e.g., saying or thinking "relax" when releasing), visualization (e.g., "imagine yourself lying on the beach") and mindfulness meditation (e.g., scanning the body in a receptive, non-judgmental way). Additionally, an implemented system will be developed and tested with human practitioners.

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