Physio-Coach

Evaluation of digital and conventional coaching methods for home-based physiotherapy exercises

Bachelor's Thesis

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Zusammenfassung

In der Physiotherapie gibt es ein anhaltendes Problem, dass Patienten sich nicht ausreichend an ihr Heimtrainingsprogramm halten, was sich negativ auf das Therapieergebnis auswirkt. Um diesem Problem zu begegnen, werden in dieser Dissertation Herausforderungen und Praktiken von Physiotherapiepatienten untersucht und das Potenzial eines digitalen Physiotherapie-Trainers (Physio-Coach) und der zwei am häufigsten verwendeten Instruktionsmethoden zur Bewältigung dieser Herausforderungen bewertet. Es wurde eine Laborstudie mit 15 Physiotherapiepatienten durchgeführt. Die Studie umfasste qualitative Interviews und verwendete unterstützende Daten, die durch einen Fragebogen ermittelt wurden. Die Ergebnisse deuten darauf hin, dass der Physio-Coach zwar einige der von den Teilnehmern angesprochenen Herausforderungen erfolgreich addressieren konnte, durch seine eingeschränkte Flexibilität und Portabilität jedoch schlecht mit den üblichen Praktiken der Teilnehmer vereinbar war. Die papier- und videobasierten Instruktionsmethoden waren in ihren Unterstützungsfähigkeiten begrenzt, schienen jedoch für Patienten mit hoher Motivation und einfachen Übungen die bessere Wahl. Es wird davon ausgegangen, dass der Physio-Coach sich wahrscheinlich für eine spezifischere Benutzergruppe mit komplexen, über einen längeren Zeitraum durchgeführten Übungen als nützlich erweisen könnte.

Abstract

A persisting problem in physiotherapy is that patients do not sufficiently adhere to their home-exercise program, which negatively impacts the therapy outcome. To address this problem in this thesis, challenges and practices of physiotherapy patients are investigated. Furthermore, the potential of a digital physiotherapy coach (Physio-Coach) and the two most common exercise instruction methods in addressing those challenges are assessed. A laboratory study with 15 physiotherapy patients was conducted. The study included qualitative interviews and supportive data elicited through a questionnaire. The results suggest that the Physio-Coach was successful in addressing several of the challenges mentioned by the participants. However, it was poorly compatible with the participants' common practices through its limited flexibility and portability. The paper- and video-based instruction methods were limited in their guidance capabilities but seemed a better choice for patients with high motivation and simple exercises. It is assumed that the Physio-Coach could prove useful for a more specific user-group which need to perform complex exercises over a long period of time.

Acknowledgements

First and foremost I want to thank Prof. Dr. Elaine M. Huang who agreed to support me in the venture of writing my thesis as a part of an external project and continuously providing me with inputs and advice. I also want to express a huge thank you to Prof. Dr. Tobias Kowatsch who welcomed me to the project, and continually motivated, engaged, and supported me with his positive attitude and professional experience. I'm greatly thankful to all participants, who generously provided their time and shared their experiences. I'm also very grateful for the support of all physiotherapists who helped in the recruitment of their patients for this study. A big thank you goes the Physio-Coach development team which skillfully adjusted the Physio-Coach to the study settings. Lastly, I want to wholeheartedly thank my family and friends who helped me to keep going when I was experiencing difficult times.

Chapter 1

Introduction

" Sustainable solutions based on innovation can create a more resilient world only if that innovation is focused on the health and well-being of its inhabitants. And it is at that point - where technology and human needs intersect - that we will find meaningful innovation. "

— Frans van Houten[1]

Physiotherapy is a widespread method for the rehabilitation of various health problems, such as chronic diseases, injuries and age-related health issues. The number of physiotherapy consultations in Switzerland has increased by 46% from 2011 until 2015 [Bundesamt für Gesundheit BAG, 2018]. The high demand for physiotherapy puts pressure on health professionals and calls for an efficient rehabilitation process.

In physiotherapy, the on-site therapy sessions with professionals are often complemented with at-home exercises. Those exercises should enhance and speed up the rehabilitation process and positively affect treatment outcomes, if performed regularly [Friedrich et al., 2005, Hayden et al., 2005, Jack et al., 2010]. However, treatment adherence, i.e. the extent to which patients' therapeutic behavior *"corresponds with agreed recommendations from a health care provider"* [Sabate and World Health Organization., 2003, p. 3], is low in various treatments [Campbell et al., 2001, Friedrich et al., 1998, Sabate and World Health Orga-

[1] Frans van Houten, CEO of Philips

nization., 2003] including physiotherapy [Austin et al., 2012, Beinart et al., 2013, Sabate and World Health Organization., 2003] where non-adherence reaches up to 70% for patients with chronic low back pain. [Härkäpää et al., 1991, Reilly et al., 1989] Furthermore, as those exercises are performed by the patients without expert supervision, the risk for incorrect exercise execution is high and can result in reduced efficacy of the treatment [Friedrich et al., 1996].

Technology can represent a solution to this problem of insufficient adherence to a treatment by providing supportive systems which increase the reach of therapists to the patients' home. The use of technology in the health sector is rising and health care systems using pervasive computing technology are gaining popularity, due to improved efficiency and reduced costs in treatments [Varshney, 2003]. Technology provides a plethora of possibilities of how to guide patients when performing at-home exercises. To this day, several rehabilitation systems have been developed in this endeavor.

The Center for Digital Health Interventions (CDHI)[2] at the Swiss Federal Institute of Technology in Zurich (ETH) developed a digital coach for home-exercises in physiotherapy (Physio-Coach). They used a combination of Augmented Reality and smartphone technology with the objective of addressing all relevant aspects of exercise adherence.

This thesis is part of aforementioned project at CDHI and investigated the suitability of different technologies and methods to guide patients in performing their home exercises. More specifically, challenges and practices of physiotherapy patients concerning home-exercises were inspected. Additionally, the patient's perception of the Physio-Coach and two conventional instruction methods as a home-exercise guidance were investigated. The following research questions are addressed in this work:

RQ1: What are the current practices and challenges of physiotherapy patients, regarding exercises at home?

RQ2: How does a digital coach for home-exercises in physiotherapy (Physio-Coach) and conventional exercise instruction methods address the challenges in RQ1?

To answer these research questions, a laboratory study with physio-

[2] www.c4dhi.org

therapy patients was conducted. Addressing the first research question, semi-structured interviews with patients were conducted, which investigated the challenges they faced when performing at-home exercises. Additionally, a literature review was carried out to investigate existing research on adherence problems and to cross-validate and extend this research.

To investigate the second research question, we conducted a user-study, where the patients tested the Physio-Coach as well as two currently most common exercise instruction methods, namely a paper- and video-instruction. A second qualitative interview was conducted afterwards to thoroughly understand how the patients experienced each instruction method and how those methods address the previously detected challenges. To support the insights from the interviews, a survey was conducted to also quantitatively evaluate our findings. Closed questions about various aspects of the user experience of the different instruction methods were posed in the questionnaire.

The following main contributions are made in this thesis:

- A preliminary evaluation of the general perception of the Physio-Coach as a health intervention for physiotherapy.
- Insights into problems and practices of physiotherapy patients with various health issues when performing at-home exercises.
- A report of the qualitative feedback of physiotherapy patients after testing the Physio-Coach as well as conventional instruction methods.
- Design implications for physiotherapy coaching systems and the Physio-Coach to better address the detected challenges from RQ1.

The thesis is structured as follows: To provide an overview of existing literature and systems addressing exercise adherence, related work is discussed in chapter 2. Next, the CDHI project and the development of the Physio-Coach are introduced in chapter 3. The study design is then explained in chapter 4, to illustrate the development of the different components of the laboratory study. The results of this thesis are presented in chapter 5 and their interpretation as well as the derived design implications are discussed in chapter 6. This is followed by a

conclusion in chapter 7. A discussion and an outlook on future work conclude this work in chapter 8.

Chapter 2

Related Work

This thesis aims to investigate patients' challenges and practices with physiotherapy home-exercises and evaluate different coaching approaches for those exercises. Therefore, first, literature on challenges in physiotherapy home-exercises is reviewed, positioning this thesis' insights within existing work. Next, existing systems which were developed to coach home-exercises in physiotherapy are presented. Finally, Augmented Reality (AR) technology and agent-based coaching are introduced to provide background information on the potential of the technology and the coaching method in supporting patients with home-based exercises.

2.1 Qualitative Research on Exercise Adherence Challenges

As this work mainly uses a qualitative approach to investigate challenges of physiotherapy patients in adhering to home-exercises, in this section existing research on this topic is reviewed.

Palazzo et al. [2016] investigated barriers to home-based exercise program adherence and patients' expectations regarding new technologies. They used a qualitative research approach and conducted semi-structured interviews with 29 patients with chronic lower back pain. In those interviews, the following barriers to exercise adherence were found, divided into four sub-categories:

The first category was barriers associated with the exercise program, such as too many exercises, a program which is too complex, or boring exercises. Secondly, barriers concerning the healthcare journey included, for example, the lack of follow-up meetings with a health care provider and difficulties contacting those. Thirdly, barriers associated with patient representations included patients' perception of the illness and the exercises as well as lack of motivation. Lastly, barriers related to environmental factors were presented, such as the absence of support from others and the lack of time.[Palazzo et al., 2016]

Patient's expectation of new technologies showed that simple reminders prompting them to exercise were not received very well. They enjoyed the idea of social networks, while expressing some concerns about privacy. Patients were interested in a tool which provides feedback on the correctness of their movements, as this enabled the patients to improve their performance. Elder people and women preferred following a virtual exercise model, while younger patients favored a challenging and game-like experience.[Palazzo et al., 2016]

This thesis builds upon and extends Palazzo et al.'s work. The thesis cross-validates Palazzo et al.'s insights on exercise adherence barriers and considers their observations regarding patient's expectations of new technologies in the proposition of design implications for the Physio-Coach.

Newman-Beinart et al. [2017] developed the Exercise Adherence Rating Scale (EARS) to measure exercise adherence in a physiotherapy setting. It was created using qualitative data from focus groups and validated an initial set of question items with a sample of 224 participants. The final scale included 6 items assessing exercise adherence behavior. An initial scale included 17 question items, additionally including reasons for adherence and non-adherence. This initial scale can be seen in table 4.2. [Newman-Beinart et al., 2017]

The EARS is used for the assessment and elicitation of challenges in home-exercises as described in section 4.3.

The previously described studies were based on the problem of insufficient frequency of exercise execution and mainly investigated barriers which keep patients from achieving such a sufficient frequency. This thesis more generally investigates challenges patients face concerning at-home exercises which keep them from experiencing a successful therapy or positive engagement. This will also provide in-

sights into how supporting technology for those patients should be designed to provide them with an overall positive experience.

2.2 Physiotherapy Home-Exercise Coaching Systems

In this section, existing coaching systems for physiotherapy home-exercises are presented. It is described how the Physio-Coach differs from those systems by introducing exercise adherence dimensions, and illustrating which dimensions are addressed by those systems and by the Physio-Coach.

Exercise Adherence. The World Health Organisation defines exercise adherence as: *"the extent to which a person's behaviour – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider."* [Sabate and World Health Organization., 2003, p. 3] To more specifically define exercise adherence, in this thesis exercise adherence dimensions are proposed, closely referring to Frost et. al's four adherence parameters *Frequency*, *Duration*, *Intensity* and *Accuracy* [Frost et al., 2017]. To more closely fit a Physiotherapy setting, those parameters were slightly adjusted and resulted in the following exercise adherence dimensions:

Frequency. This dimension is in line with Frost et al.'s parameter *Frequency* [2017] and concerns the number of times per time-unit (e.g. week) the exercise sessions are performed.

Number of exercises. A home exercise session in physiotherapy usually includes multiple different exercises with a number of sets each. This dimension refers to whether all prescribed exercises were performed. The dimension is related to Frost et al.'s *Duration* aspect [2017], adjusted to a physiotherapy setting.

Repetitions. Adherence to the recommended number of repetitions relates to the *Intensity* parameter of adherence in Frost et al. [2017] which stands for the amount of work a patient has to invest in doing an exercise [Page et al., 2012], which, in a physiotherapy setting, is often measured using the number of repetitions.

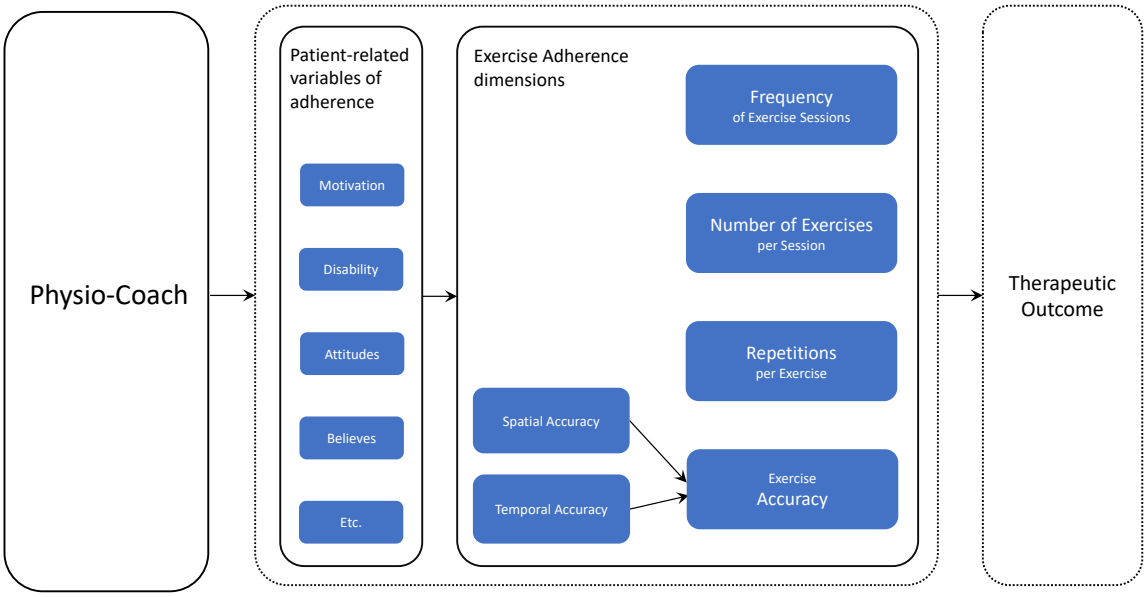


Figure 2.1: The relation between the Physio-Coach, exercise adherence and the therapeutic outcome. The Physio-Coach addresses exercise adherence, which in turn influences the therapeutic outcome. Exercise adherence includes four dimensions, namely frequency, number of exercises, repetitions and accuracy. Those dimensions can be influenced by patient-related variables of adherence.

Accuracy. This dimension corresponds to Frost et al.'s *Accuracy* parameter [2017]. It can be divided into two sub-dimensions concerning spatial and temporal accuracy. Spatial accuracy of an exercise refers to whether the body parts follow the correct trajectories in space. Temporal accuracy refers to whether an exercise is performed at the right speed.

An additional measure to assess how a system addresses exercise adherence is to determine how patient-related variables ("individual patient variables" in [Beinart et al., 2013]) such as motivation, pain level or beliefs about the exercises are addressed by a system, which can have an influence on the adherence dimensions. [Beinart et al., 2013]

Those patient-related variables are illustrated in figure 2.1 along with the relevant dimensions of adherence and the relation between the Physio-Coach, exercise adherence and the therapeutic outcome.

Related Coaching Systems. Several rehabilitation systems have been developed to coach physiotherapy home-exercises. They use varying technologies and often target certain types of health problems. In the following paragraphs those systems are introduced, along with an illustration of which exercise adherence dimensions they address.

Tang et al.[2015] developed a system for guiding upper limb physiotherapy exercises at home. The movements were guided by a sophisticated visual feedback on a TV-Screen comparing desired and actual movement in different variables of exercise execution. This system very thoroughly provided accuracy feedback, however other factors of exercise adherence were not considered.[Tang et al., 2015]

A mixed reality system using interactive projections in a room by Di Loreto and Gouaïch [2011], was developed to guide patients to perform exercises for the rehabilitation of the upper limbs. It uses a "serious games" approach and should ensure a correct execution of the exercise through the game design. In this approach, patient related variables are addressed as the game should motivate the patients through gamification elements, but no functionality to encourage frequency of exercise execution was implemented.[Di Loreto and Gouaïch, 2011]

VRHealth[1] is a rehabilitation system which uses virtual reality technology and provides several games embodying physiotherapy-like exercises. The games are focused on the rehabilitation of the upper body. The system enables monitoring by physiotherapists and tracks progress. While they motivate the patients through a playful experience, no guidance on the frequency dimension is provided and they do not encourage the execution of all prescribed exercises, based on the information available. [VRHealth, 2018]

Kaia Health[2] [Huber et al., 2017] is a mobile application which guides the user through various exercises for back pain using video instructions and provides feedback on spatial accuracy using a body-scan function. It also reminds the user to perform exercises on specified days and counts the number of repetitions. However, the speed of the execution is not considered and it seems that no measures to address patient-related variables are taken. [Huber et al., 2017]

Clark et al. [2018] created a web-based educational service, which

[1] www.xr.health
[2] www.kaia-health.com

System	Technology	Patient-related variables	Frequency	Number of exercises	Repetitions	Accuracy	
						Spatial	Temporal
Tang et al.	Sensors & TV-Screen						
Di Loreto & Gouaïch	Mixed reality projections						
VRHealth	Virtual Reality						
Kaia Health	Mobile app						
Clark et al.	Web-platform						

Table 2.1: Related technologies addressing adherence dimensions and patient-related variables. Green: addressed, yellow: partially addressed, red: not addressed, white: not applicable.

provides videos, animations and photos as exercise instructions and the patients' progress is tracked by having the patients create action and coping plans and it includes reminder functions. Patient-related variables are addressed, as well as frequency, but number of exercises and repetitions only partly, since the patient has to manually track those. No accuracy feedback is provided. [Clark et al., 2018]

In Table 2.1 it can be seen that only parts of the adherence dimensions outlined in figure 2.2 are addressed within one system today. The tendency is that systems either focus on ensuring a correct performance or on motivating the patients to perform their exercises with a sufficient frequency. The Physio-Coach was designed to address all dimensions of exercise adherence and to thereby achieve a wholesome positive impact on patients' exercise behavior. This thesis attempts to assess whether this design reasoning has the potential to address the challenges experienced by physiotherapy patients.

2.3 Augmented Reality

In this section, AR technology is introduced, to provide a background on the main technology used in the Physio-Coach and present the technology's potential in a physiotherapy coaching setting.

AR is defined in Azuma's work as a system which combines virtual

and real elements, is interactive, and operates in three dimensions. [Azuma, 1997] Based on Milgram et al.'s Reality-Virtuality Continuum [1995], in AR the focus is more on the real, rather than the virtual environment and this real environment is merely enhanced by virtual objects. AR falls in the category of Mixed Reality (MR) which describes an environment made up of a combination of real and virtual elements. [Milgram et al., 1995] While this thesis is focusing primarily on AR, relevant literature using the more general term MR is also considered.

AR environments can be created using various technologies, examples are head-mounted displays (HMD) ("See-through" AR displays), monitor based AR [Milgram et al., 1995], projections on objects in a room [Di Loreto and Gouaïch, 2011, Funk et al., 2015] or even on body parts [Sodhi et al., 2012]. The advantage of HMDs compared to projection systems is the relatively lower setup-costs and the higher sense of presence for the user [Milgram et al., 1995]. A disadvantage could be the increased burden for the user, by carrying the device on their head.

In HMD technology, virtual elements are projected on see-through glasses. The AR-system of the Physio-Coach was developed using Magic Leap One glasses[3]. Using this technology, realistic visualizations can be created which interact with the user as well as with the real environment, such as walls and tables. This is facilitated through various features such as sensors for the head position, eye-tracking, depth-sensors or gesture recognition. [Haselton, 2018, Ashley, 2018].

Concerning the suitability for a physiotherapy coaching setting, AR offers a variety of functionalities which could potentially prove useful for an exercise coaching situation. AR technology can provide movement feedback based on sensor data, communicate complex information through multiple channels and provide an enjoyable experience by elements of gamification and interactivity with virtual objects. Palazzo et al.'s work [2016] showed, that patients expect new technology to provide those mentioned functionalities, namely feedback, an enjoyable and challenging experience as well as guidance while performing the exercises at home[Palazzo et al., 2016].

AR further enables the realistic and interactive representation of complex objects such as virtual agents, which are discussed in the next section.

[3] www.magicleap.com

2.4 Agent-Based Coaching

As the Physio-Coach is using a virtual agent to guide through the physiotherapy exercise, in this section agent-based coaching is introduced. A definition of an agent in AR is presented as well as the capabilities of AR-agents in a coaching situation.

Laurel [1997] describes agents as characters enacted by the computer to help users in various ways, by providing advice and support while interacting in an intuitive and natural manner. An agent is meant to be not merely a tool, but an assistant.[Laurel, 1997]

Agents in mixed reality were defined by Holz et al. [2011] as *"an agent embodied in a Mixed Reality environment."* [Holz et al., 2011, p. 252] Based on this definition Campbell et al. [2014] proposed the notion of an AR agent which is an MR agent *"that can both sense and act in the virtual component of their reality but can only sense in the physical."* [Campbell et al., 2014, p.140]

Using virtual agents in health interventions can have positive effects [Bickmore et al., 2005]. As humans interact similarly with computers (and agents) as they do with other humans [Reeves and Nass, 1996], they can build a working alliance with a virtual agent[Bickmore et al., 2005]. A working alliance is a psychological collaboration quality [Horvath and Greenberg, 1994] which can be built between a user and a relational agent and can facilitate long-term engagement in a health intervention[Bickmore et al., 2005].

An AR-agent can be particularly useful in a physiotherapy coaching setting for the following reasons: The agent can represent the role of an instructor and realistically illustrate and demonstrate a movement. This demonstration can be showed from multiple perspectives [Han et al., 2017] and include motivating game-like components [Doswell and Harmeyer, 2007]. Furthermore, movement feedback can be provided using a realistic interface and embodiment in 3D space and could exploit various means of visualization. Lastly, in Palazzo et al. 's [2016] study, it was found that elder physiotherapy patients were interested in following a virtual agent.

Chapter 3

Project Description

To provide a context for the thesis, the project at the Center for Digital Health Interventions (CDHI)[1] is introduced in this chapter. Furthermore, the development of the Physio-Coach and the embedding of this thesis within the overall project are explained.

The project is a collaborative study between the CDHI at the Swiss Federal Institute of Technology in Zurich (ETH), the University of Zurich, the University of St.Gallen and the Applied Health Care Center in Bern [2].

The CDHI is a research center at ETH which develops digital health interventions, using various technologies. While in recent projects, such as the MobileCoach[3] [Barata et al., 2016], the intervention was based on smartphone technology, in CDHI's study on the development of the Physio-Coach, a digital solution was created using both smartphone and AR-technology. This combination should enable the support of physiotherapy patients along all exercise adherence dimensions.

The Physio-Coach was developed using AR-glasses of Magic Leap, namely the Magic Leap One Creator Edition[4] and implemented using Unity Technology[5]. For simplicity and demonstration purposes, only

[1] www.c4dhi.org
[2] www.applied-health-care.ch
[3] www.mobile-coach.eu
[4] www.magicleap.com
[5] www.unity3d.com

one exercise was implemented, namely the exercise known as 'squat'.

To this point, two versions of the Physio-Coach have been developed. The first version was developed and tested as a preliminary evaluation (section 4.2.), the second version was built based on the preliminary evaluation's feedback and tested within the scope of this thesis. While the first version was only based on the AR-system, the second prototype included a mock-up of a smartphone application and a paper-based patient-card. In the following paragraphs the two versions are presented.

The scenario in the first prototype included two virtual characters. The first is Max (figure 3.1, right), an agent who appeared similar to a super-hero, and was framed as a digital assistant of an existing physiotherapist. Max introduced himself and guided the user through an exercise session. The second character was a female exercise model, which demonstrated the exercise execution. First the model showed a few executions of the squat and then Max engaged the user into performing the exercise too. The interaction with Max was conversation-based and implemented by touching virtual answer-option buttons. This interaction was also implemented in the second version.

The second version of the Physio-Coach was a combination of an AR-system, a mock-up of a smartphone application and a small patient information card.

Patient Card. The first component is a patient card with the patient's name and patient-code. Printed on the card is a QR-Code which should lead to a website where the mobile application "Max - your Physiocoach" could be downloaded. The QR-code should additionally encode the patient's information, so that the mobile application will already have information such as the responsible therapist and prescribed exercises. Those functionalities were not implemented yet, but the template can be seen in figure 3.2.

Smartphone application. The smartphone application is designed to work as a reminder and motivator for the patient to perform the exercises on a regular basis. This should address the frequency dimension of adherence and target patient-related factors such as motivation and beliefs about exercise benefits. The mobile application

would hold information about the physiotherapy exercises and include a conversational agent called Max. Max would introduce himself to the patient and prompt notifications to remind the user to do the exercises. Max also emphasizes that the exercises are beneficial for the patient, which should have a positive effect on the patient's attitude towards the therapy [Morrissey et al., 2016]. When it is time for the exercises, Max instructs the patient to start the AR exercise program. A Mock-up of the smartphone application can be seen in figure 3.3.

AR-system. The AR-system guides the patient trough the whole exercise session and provides feedback on spatial and temporal accuracy as well as the number of repetitions and sessions to be completed. Thereby it addressed all exercise adherence dimensions except frequency. The implemented procedure assumed a first-time user, and therefore included a short tutorial on how to interact with the objects in AR. When starting the exercise session, Max first informs the patient about how a squat is performed correctly and what are important points to consider when performing a squat. Max then demonstrates the execution of a squat and arrows are highlighting the important areas on Max's body which refer to what he is currently explaining. Next, Max motivates the user to join and to try performing the squat. After a few test-squats, the patient can perform the recommended number of sets and repetitions, which Max is counting out loud for the user while supervising the execution. Feedback is provided after a couple of executions of the exercise, to not overwhelm the user with feedback after each execution but still offering information about errors in the movements. The feedback is based on a comparison between the patient's movement data gathered through the AR-system and movement data collected from a physiotherapist performing the squat. When the deviation surmounts a certain threshold, an error is registered. For example when the movement is skewed too much to the right or left, or if the speed is too high or low, Max would tell the user to take care of that aspect. After the session ends, Max praises the patients and gives them a ”high-five”.

This thesis was positioned within the study at CDHI as follows: It conducted a preliminary evaluation of the first version and collected qualitative and quantitative feedback on the second version of the Physio-Coach. Based on how well the Physio-Coach addressed the patients' challenges, the thesis proposed design implications for the further development of the Physio-Coach. The study at CDHI will

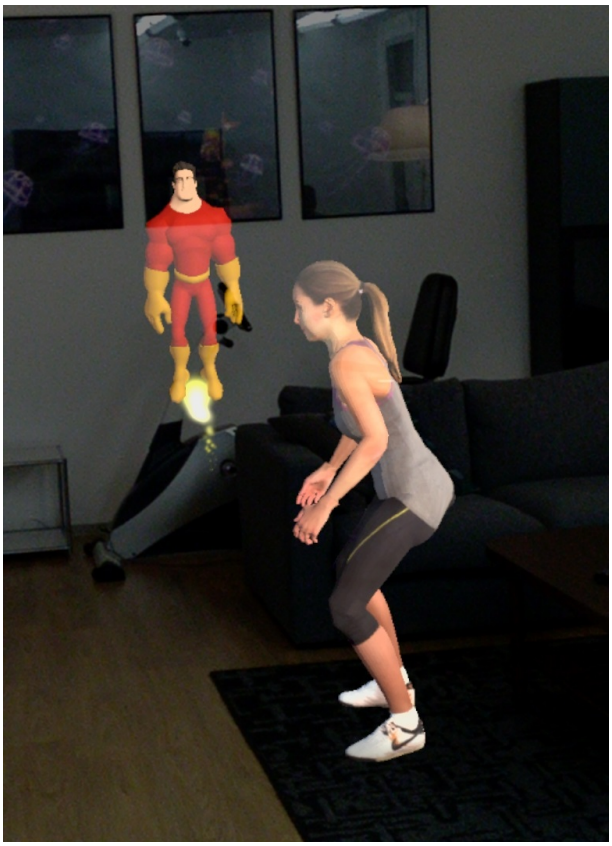


Figure 3.1: First version of the Physio-Coach, Max (left) and an exercise model (right) are instructing the squat.

further utilize additional data collected during the lab study, such as responses to the BORG-Rating scale [Borg, 1990] as well as the performance assessment of the participants' exercise execution. The analysis of this data was out of the scope of this thesis.

Figure 3.2: Patient card to download "Max - your Physiocoach" mobile-application.

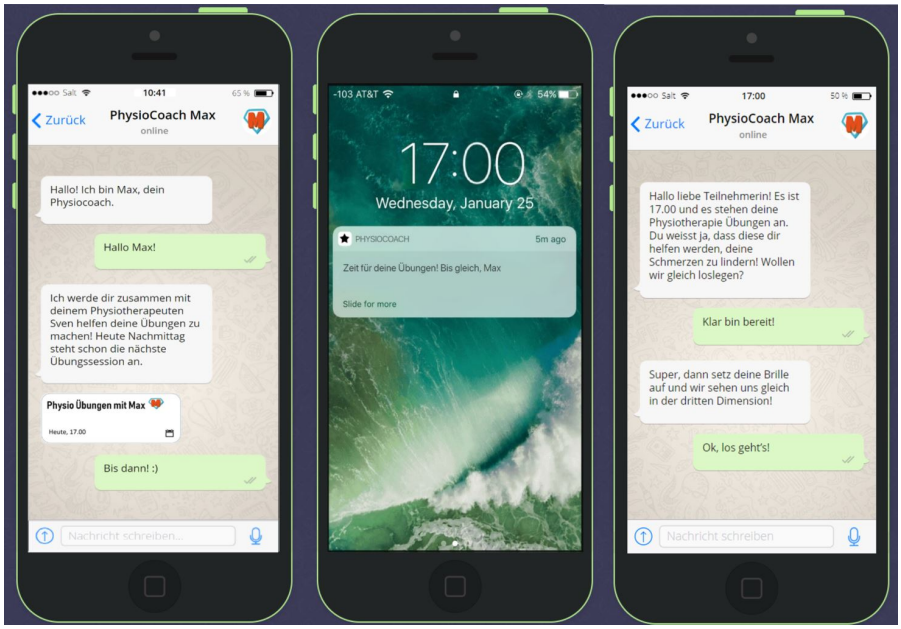


Figure 3.3: Mock-up of the smartphone application "Max - your Physio-Coach".

Figure 3.4: User wearing Magic Leap One glasses.

Figure 3.5: Max, the virtual instructor in second version of the Physio-Coach.

Chapter 4

Study Design

In this chapter, the design of the study is presented. For this, the overall procedure is explained and the methodologies that were applied for the preliminary evaluation and for the different components of the laboratory study are going to be outlined.

4.1 Overall Procedure

The procedure applied in this thesis is divided into two main parts, a preliminary evaluation and a laboratory study. The preliminary evaluation (section 4.2) was a first assessment of how the first version of the Physio-Coach is perceived by a broader audience and complemented the laboratory study by offering a notion on people's impression of the Physio-Coach's functionality and potential. The laboratory study (sections 4.4 - 4.6) evaluated the second version of the Physio-Coach. It included multiple components which jointly addressed the research questions described in chapter 1. How the research questions are addressed by elements of the laboratory study is presented in the following paragraphs.

The first research question (*"What are the current practices and challenges of physiotherapy patients, regarding exercises at home?"*) was addressed using a combination of a semi-structured interview (section 4.4.1) and the Exercise Adherence Rating Scale (EARS, section 4.4.2) [Newman-Beinart et al., 2017]. The EARS is a scale, measuring exercise adherence

of patients by assessing multiple items concerning adherence behaviors and factors. The interview enabled in-depth insights into challenges and practices of physiotherapy patients by encouraging them to elaborate on their experiences and problems they faced concerning their physiotherapy home-exercises. The EARS complemented the interviews' insights with an established measurement from existing literature to measure exercise adherence and enabled a prioritization of the challenges mentioned by the patients. The interview was the first component of the laboratory study, took approximately 20 minutes, and was followed by the participants filling out the EARS (Table 4.1).

Time (min)	**Content**
5	Introduction, information sheet and consent form
20	**Semi-structured interview about challenges and practices**
3	Exercise Adherence Assessment Scale
3	**Scenario 1**
3	Instruction assessment questionnaire 1
3	**Scenario 2**
3	Instruction assessment questionnaire 2
3	**Scenario 3**
3	Instruction assessment questionnaire 3
4	Ranking and comparison questionnaire
10	**Semi-structured interview eliciting feedback and overall assessment**

Table 4.1: The timeframe of the experiment including interviews, scenarios and questionnaires.

To address research question two (*"How does a digital coach for home-exercises in physiotherapy (Physio-Coach) and conventional exercise instruction methods address the challenges in RQ1? "*), a user-study was conducted. In the user-study, patients tested the Physio-Coach and two most common exercise instruction methods and provided feedback about their experience using these instructions. This provided insights

into how the different methods address the patient's existing problems and resulted in implications on how the Physio-Coach could be improved to address them to a further extent.

The user-study was conducted in 3 conditions using three scenarios (Section 4.5), representing each instruction method. Each participant tested all methods (within-subject) in a randomized order to account for learning effects. The laboratory study took approximately one hour and the time-frame is illustrated in table 4.1.

The participant's feedback on the instruction methods was collected using a semi-structured interview (section 4.6.1) and a closed question questionnaire (section 4.6.2). The combination of those methodologies enabled an in-depth investigation on the experience of the patients when using the different instructions, and the questionnaire offered supportive data for the interview insights by providing responses concerning various dimensions of user experience. This also facilitated an easier comparison between the methods and could complement the themes which have emerged from the interviews.

Following the laboratory study, the collected data was thoroughly analyzed. The methodologies used for the data analysis are described in section 4.7.

4.2 Preliminary Evaluation

To gather feedback on the first version of the Physio-Coach, a preliminary evaluation was conducted. The design of this evaluation is described in the following paragraphs.

The CDHI received the opportunity to present the first version of the Physio-Coach publicly on the Digital Day Switzerland [1] a public fair at the main station in Zurich. There, the prototype could be tested by anyone interested. This was a great occasion to gather first feedback on the Physio-Coach. For that purpose, a questionnaire was created to be completed by the participants after testing the Physio-Coach.

The questionnaire was designed to elicit information which could provide first insights for this thesis' research questions. The questionnaire

[1] www.digitaltag.swiss

should reveal how the Physio-Coach is perceived by a broad audience, eliciting user-experience, information on what physiotherapy patients consider their biggest problems with home-exercises and how they think the Physio-Coach could be improved. Furthermore, the results of the questionnaire influenced the development of the second version of the Physio-Coach as described in chapter 2.

The questionnaire was designed as follows: At first, demographic information such as gender, age, and whether the participant is a desktop-worker or has previous experience with technology was collected to provide a context for the following feedback.

Then four questions assessing the user experience were asked. Perceived enjoyment [Kamis et al., 2008], perceived ease of use, perceived usefulness [Davis et al., 1989] and intention to further use [Venkatesh et al., 2003] from the Technology Acceptance Model [Davis, 1985], were prompted in a seven-item likert-scale format.

The remaining questions were only posed if the participants had previous experience with physiotherapy. In this section it was asked whether the participants believed their frequency and accuracy of exercise execution to be sufficient and what they consider the biggest problems with performing physiotherapy exercises at home.

Towards the end, the participants with experience in physiotherapy were invited to propose ideas of how the physiotherapy coach could be improved such that it could be used better for exercises at home. Finally, they should rate the degree to which they would recommend the coach to other physiotherapy patients.

The questionnaire was designed to be filled out in parts by the participants themselves (user experience questions) and in part by a member of the project, together with the participants (questions about physiotherapy problems and Physio-Coach improvement suggestions). Through this approach the participants were encouraged to create their own propositions before seeing a set of predefined answers.

The questionnaire used for the preliminary evaluation can be found in appendix A.

4.3 Laboratory Setting & Participants

In this section, the setting as well as the participants of the laboratory study are described.

The laboratory study was conducted at the Applied Health Care Center (AHC)[2] in Bern. The study took place in the facilities of the center, in different rooms of similar size and equipment.

As mentioned in section 4.1, the order in which the three different instruction methods were tested was randomized, to account for learning effects. However, due to the small sample size, it was ensured that every possible combination of instructions occurred roughly equally often and thereby some sequences were adjusted. The distribution of the sequences can be seen in table 4.2.

The laboratory study was conducted with 15 participants. The majority of the participants were in physiotherapy at the AHC while some patients were from other physiotherapy centers. Requirements for participation were legal age, fluent German skills, currently in physiotherapy treatment and having completed at least 3 sessions, never having performed the squat as a physiotherapy exercise (outside the therapy was possible), being in the physical condition to perform a squat, normal vision or contact lenses, and normal hearing.

Table 4.2 illustrates the participants. The mean age was 37 and there were 5 male and 9 female participants. 13 participants had no or little experience with AR and 2 participants had experience with AR.

4.4 Home-Exercise Challenges & Practices

This section presents the methodologies used to investigate challenges and practices of physiotherapy patients concerning home-exercises and the design of those methodological components.

To gain wholesome insights into home-exercise challenges, a semi-structured interview was combined with the EARS. This enabled the amalgamation of qualitative insights and existing empirical research

[2] www.applied-health-care.ch

ID	Sequence	Sex	Age	Experience AR
P1	2,1,3	M	57	Little
P2	2,3,1	M	24	No
P3	1,3,2	M	46	Little
P4	2,3,1	M	32	No
P5	1,2,3	F	43	Little
P6	3,2,1	M	41	No
P7	3,1,2	F	21	Yes
P8	1,3,2	F	23	Little
P9	3,1,2	F	37	Yes
P10	2,3,1	F	48	No
P11	1,2,3	F	30	No
P12	1,2,3	F	32	Little
P13	2,1,3	F	47	No
P14	3,2,1	M	35	Little
P15	3,1,2	F	39	Little

Table 4.2: Participants of laboratory study. Instruction method 1 = Paper-instruction, 2 = Video-instruction, 3 = Physio-Coach

on challenges physiotherapy patients face when performing home-exercises. The following sections thereby present the design of the interview guide and introduce the EARS.

4.4.1 Interview Guide

The interview seeks to elicit information about challenges and practices concerning physiotherapy exercises at home.

After an initial set of focus questions was composed, an interview guide was created and iteratively revised during the conduction of 6 test-interviews.

The design of the interview guide was informed by methods of qualitative interview studies by Weiss [1995]. For a successful interview, the wording of the interview questions should be specific and encourage the patient to provide concrete descriptions of scenes and events relevant to the topic. The patients should be able to speak freely and in detail about their experiences. Furthermore, the transitions between topics should be as smooth as possible and the order of questions

should not interrupt the participants' train of thought more than three times. This guidelines are meant to ensure an ongoing interview partnership and an efficient interview conduction. [Weiss, 1995]

Six test interviews were conducted, where the interview guide was continuously revised and improved in line with the recommendations of Weiss [1995]. Some improvements in the interview guides were the following:

The interview guide was adjusted from German to Swiss-German as Swiss-German was the language of interview conduction and most natural for the majority of the participants. The order of questions was revised to ensure a natural conversation flow and additional questions were included. The interviewer's practice of interrogation was improved by learning how to dig deeper on specific aspects and by making notes during the interview.

The final interview guide contained the following questions:

- Can you tell me about how you started physiotherapy?
- How often do you see the physio therapist?
- Could you walk me through your last physiotherapy session with the therapist?
- How did the therapist inform you to do home-exercises?
- After that session you went home and when did you do the home exercises?
- Can you walk me through the last time you did physio exercises?
- When you are doing the exercises, do you do anything else at the same time?
- What was going through your mind, when you did the exercises?
- Can you tell me about a time when you did the exercises which was particularly difficult or problematic?
- Can you explain in detail what happened?
- Is there anything you especially enjoy or dislike about doing the exercises?
- When you do the exercises, what do you do to motivate yourself?
- What do you think about the frequency of doing the exercises at home?
- Do you do anything to help yourself remember to do the exercises?
- Do you ever miss a day, and if so is there anything you do to deal with that?

- How do you feel about the correctness of the exercises you are doing?
- What do you think about the speed with which you do the exercises?
- What do you think about the amount of repetitions you do per exercise?
- Are there exercises you skip and if so why?
- What do you think the physiotherapist thinks of how you are doing the exercises?
- How do you feel about doing at-home exercises?
- Do you feel that you receive benefit from doing the exercises?
- What is your experience with exercising in general, besides physiotherapy?
- How do you combine physiotherapy exercises with your usual (exercise) routine?

4.4.2 Exercise Adherence Rating Scale

The EARS was developed by Newman-Beinart et al. [2017] who's work is presented in section 2.2.

EARS was included in this thesis for an additional numerical assessment of exercise adherence. It revealed how much different factors of exercise adherence contribute to a resulting overall score. As previously described, the final EARS in Newman-Beinart et al.'s work [2017] is made up of 6 items assessing adherence behavior, while the initial core questionnaire included 17 items also assessing reasons for adherence and non-adherence. In this thesis, the remaining 11 items are also included, to be able to make more connections to the interview's insights and draw a more differentiated picture of factors contributing to exercise adherence.

Table 4.3 illustrates the questionnaire items of the EARS.

4.5 Scenarios

The testing of the instruction methods was embedded in scenarios, which should realistically imitate how the instruction methods are commonly used or how they are meant to be used in the case of the Physio-Coach. Therefore, this section presents the selection process

1	I do my exercises as often as recommended*
2	I adjust the way I do my exercises to suit myself
3	I don't get around to doing my exercises*
4	Other commitments prevent me from doing my exercises
5	I feel confident about doing my exercises
6	I don't have time to do my exercises
7	I'm not sure how to do my exercises
8	I do some, but not all, of my exercises*
9	I don't do my exercises when I am tired
10	I do less exercise than recommended by my healthcare professional*
11	I fit my exercises into my regular routine*
12	I do my exercises because I enjoy them
13	My family and friends encourage me to do my exercises
14	I stop doing my exercises when my pain is worse
15	I forget to do my exercises*
16	I do my exercises to reduce my health problem
17	I continue doing my exercises when my pain is better

Table 4.3: Seventeen core questionnaire items for the Exercise Adherence Rating Scale by Newman-Beinart [p. 181][2017]. *Items assessing adherence behaviour directly. Remaining items assess reasons for adherence/non-adherence

of the instruction methods to be tested and explains the scenarios in which those instructions are presented to the participants.

4.5.1 Selection Procedure & Content

To compare the status quo of supportive methods for physiotherapy patients in doing their home-exercises to the Physio-Coach, a small-scale telephone survey with physiotherapy offices in Switzerland was conducted. The goal of the survey was to determine the prevailing way of informing and supporting physiotherapy patients concerning their home-exercises.

Through a random selection of physiotherapy offices in Switzerland registered by the Physio-Swiss[3] organization's index of physiotherapist, roughly 44 physiotherapy offices were contacted, however only 14 offices were able to provide information about their practice. There

[3] www.physioswiss.ch

were four main ways how physiotherapists provided guidance to the patients concerning at-home exercises.

All physiotherapists reported that they first explain and demonstrate the exercises which they prescribe to do at home. Then they supervise how the patient performs the exercises during the therapy session and correct the patient until he/she is able to perform it correctly.

The results of the telephone survey are illustrated in table 4.4. The most prevalent home-exercise instruction was a hand-written explanation of the exercise with sketches of the movement. The second most frequently mentioned method was a video instruction. Thirdly, several therapists claimed to use printed exercise-instruction sheets most frequently and the same number did not use any additional instruction aid. One office mainly used a smartphone application. The detailed survey notes are provided in appendix C.

	Instruction method	**#Physiotherapists**
1	Hand-written instruction	8
2	Video instruction	5
3	Printed instruction	3
3	No instruction	3
4	Mobile Application	1

Table 4.4: Telephone-survey results - Most common exercise instruction methods

The scenarios are therefore based on a hand-written instruction on paper and a video-instruction, due to their popularity reported in the survey. The third scenario represents the Physio-Coach. The scenarios were prepared to most similarly reflect the situation described by the therapists.

All three methods provided an instruction on how to perform a squat. The information concerning the correct execution of a squat was provided by a physiotherapist and was consistent in content and amount over all instruction methods.

In the following subsections the scenarios for the user-test are presented.

4.5.2 Paper-Instruction

Even though static visualizations (paper-based) proved inferior to dynamic visualizations (video) for movement instruction [Castro-Alonso et al., 2014] the ongoing prevalence of this instruction method could bring about interesting preferences and factors to consider in the design for home-exercise guidance.

In the telephone survey, a hand-written instruction was described as follows: After an explanation and demonstration the exercises, the therapist writes explanations of how to perform each exercise on a paper with the number of repetitions and sets to be performed and some important information about the exercise execution. To illustrate the movement trajectories, a simple human figure (”stick-figure”) in different stages of the exercise execution is drawn on the paper. The instruction-sheet is handed to the patient to use as a reference when performing the prescribed exercises.

To closely imitate this real-life scenario in the laboratory study, a physiotherapist was asked to write down a description of a squat and illustrate it as he would do it with his patients. The amount of information provided on this sheet was slightly shortened for consistency reasons and then handed over to the participants in the user-study. The instruction sheet can be seen in figure 4.1.

The participants were asked to imagine the following scenario: ”You had your therapy session yesterday, where your therapist explained and demonstrated the squat, made you perform it a few times and made sure it was correct. Your therapist then wrote down and illustrated what he had told you about the squat execution, and handed this [participant is given instruction sheet] instruction-sheet to you, to take home as a reference. Now you are at home, you should perform the exercise and you can use the provided instruction-sheet.”

4.5.3 Video-Instruction

As the telephone survey revealed, the most common scenario using video is that patients are recorded by the therapist in the therapy session while performing their prescribed exercise, once they were able to execute it correctly. The therapists reported to be using the patients’

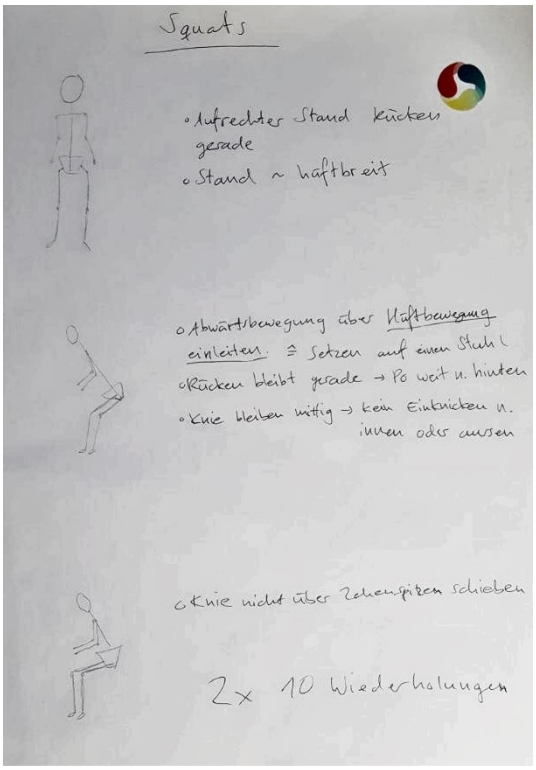


Figure 4.1: Paper-based instruction sheet describing the execution of a squat, as handed to the participants.

own smart-phone to do so. Therefore, the patients are eventually provided with a video of themselves performing the exercises correctly.

To emulate this scenario, a video showing a physiotherapist performing the squat in a correct manner was created. In a voice-over the exercise execution was explained using the same information as with the paper-instruction. The video is presented to the participants on a smartphone and a screenshot can be seen in figure 4.2.

The scenario described to the participants before using the video instruction is the following: "You had your therapy session yesterday, where your therapist explained and demonstrated the squat, made you perform it a few times and made sure it was correct. Your therapist then sent you a video to your smartphone which shows a person performing the squat correctly and includes some explanation on how to do the squat. Now you are at home, you should perform the squat exercise session and you can refer to this video using your[participant

Figure 4.2: Video-instruction shows a physiotherapist performing a squat.

is handed a smartphone] smartphone.

4.5.4 Physio-Coach

The scenario using the Physio-Coach illustrates how the system would be used in the future when all functionalities are implemented. The AR-system was fully functional at the point of testing, however the patient card and mobile application were mock-ups created to demonstrate the planned functionality. A detailed description of the Physio-Coach can be found in chapter 3.

The scenario is presented to the participants as follows: "You had your therapy session yesterday, where your therapist explained and demonstrated the squat, made you perform it a few times and made sure it was correct. Your therapist then hands you a small card with your name, patient code and a QR code. The QR code leads to a website with an installation link for a mobile app on your smartphone where your patient information is already encoded. Today morning you installed the app, which looks like this [show participant mock-up of mobile-app on smartphone]. A digital assistant called MAX is introducing himself and he now just reminded you to perform the exercises. Max instructs you to wear your AR-glasses and together with the virtual coach you perform the prescribed exercises."

4.6 User Feedback

This section presents the methodology applied to elicit the user feedback following each scenario.

The feedback was collected through a semi-structured interview combined with a closed question questionnaire. The combination of those methodologies enabled a wholesome assessment of various aspects of the user experience in each scenario. The combination also enabled a thorough understanding of this user experience and the connection to challenges discovered in the first part of the evaluation.

The questionnaire was completed by the patients after each scenario. The feedback interview took place at the end of the experiment. Even though the questionnaires were completed earlier in time, the design of the feedback interview is presented first hereafter, to emphasize the main focus of this thesis and to ensure consistency with the rest of this thesis' structure.

4.6.1 Interview Guide

In the interview, the patients were encouraged to provide their feedback on each instruction method. The participants were invited to explain how they experienced those methods and how they estimate those instructions to address the challenges they mentioned in the previous interview.

The interview duration was approximately 10 minutes. The following questions served as a guide for the second interview:

- How did you experience the paper/video/Physio-Coach instruction method?
- Which instruction did you prefer?
- Why did you prefer that instruction?
- How did the different instruction methods address the problems we previously discussed? [Referencing to notes about problems mentioned in first interview]
- Do you have any suggestion on how the Physio-Coach could be improved?

4.6.2 Questionnaire

The questionnaire assessed how the patients perceived each instruction method and provided supportive data for the qualitative insights from the interviews. In the survey various aspects of the user experience were investigated.

After each scenario, patients completed an instruction assessment questionnaire. This questionnaire was the same for all instruction methods, while including an additional set of questions for the Physio-Coach (see Session Alliance Inventory below). Finally, after all scenarios were completed, a final question prompted the patients to rank the instruction methods and elaborate on the reasons for their ranking.

The survey combined established question items from related research with a set of additional questions developed to target specific aspects of the user experience. The following questions were included.

Technology Acceptance. To provide insights into how the patients perceived the different instruction approaches, the first questions were based on the Technology Acceptance Model [Davis, 1985]. Those questions assessed perceived ease of use, usefulness and enjoyment [Davis et al., 1992] when using an instruction method, and intention to continuously use a particular instruction method [Davis et al., 1989].

- The [instruction method] was fun to use.
- I could understand the [instruction method] very easily.
- I found the [instruction method] useful to be reminded to do the exercises.
- The [instruction method] motivated me to do the exercises.
- The [instruction method] helped me to do the exercises correctly.
- How much would you like to continuously use the [instruction method]?

Task Load Index. To provide insights into how mentally demanding the participants found each method and how they felt during the scenario, the following questions, based on the Task Load Index [Hart and Field California Lowell Staveland, 1988], were included. They address the mental effort and frustration related to performing the exercises with each instruction method.

- How much mental and perceptual activity was required with the [instruction method]?
- How frustrated (insecure, discouraged, stressed versus secure, content, relaxed) did you feel during the execution with the [instruction method]?

Session Alliance Inventory. To assess the working alliance, which is a psychological collaboration quality built between a user and a relational agent [Horvath and Greenberg, 1994], the Session Alliance Inventory [Falkenström et al., 2015] was included. This 6-item measurement assessed the degree to which a working alliance between the participant and the digital coach Max could be established. Those questions were asked only once after the scenario with the Physio-Coach. Some of the questions were potentially difficult to assess after one interaction with the virtual coach, however the inclusion of the inventory could provide insights into how the relation with the virtual coach was perceived and thereby assess the general perception of Max by the participants. The assessment items were:

- Max and I respect each other.
- I feel that Max appreciates me.
- I feel that Max cares about me even when I do things that he/she does not approve of.

- Max and I are working towards mutually agreed upon goals.
- Max and I agree on what is important for me to work on.
- I believe the way Max and I are working with my problem is correct.

The first three questions address the bond with Max, i.e. the personal attachment , while the latter three questions are assessing the perception of mutual tasks and goals. [Horvath and Greenberg, 1989]

Additional Questions. The remaining questions were developed to specifically target aspects related to either the execution of the exercise or the instruction method. The first two questions assessed whether it was perceived difficult to perform the exercise and to what extent the participant perceived the execution as correct. The other three questions concern the instruction method and investigate the method's ability to convey the information required for performing the exercise, as well as how trustworthy this information appeared. Eventually the comfort of the instruction method was assessed.

The questions were developed to target specific aspects of the instructions and sought to confirm the assumption of possible differences between the instruction methods concerning those aspects. The questions were:

- How simple/difficult was it to do the exercise?
- How correct/incorrect do you think you performed the exercise?
- How informative was the [instruction method] in explaining the exercise?
- How trustworthy did you perceive the information provided by the [instruction method]?
- How comfortable was it to do the exercise with the [instruction method]?

4.7 Data Analysis

In this section, the techniques used for analyzing the retrieved data from the interviews and questionnaires are presented and it is elaborated why those methods were selected.

4.7.1 Interview Analysis

To gain a thorough understanding of the patients' inputs concerning challenges and practices in physiotherapy as well as concerning the feedback on each instruction method, the interviews were audio-recorded and partially transcribed. This transcription prepared the data for further processing and enabled the detection of patterns and common themes.

Due to time constraints, the interviews were only partially transcribed. However, only excerpts which were clearly not relevant to the cause were not transcribed. Examples of left out dialogues were clarifying explanations by the interviewer or patients' description of details about their medical condition. The software used for the transcription was f4transkript[4].

The transcribed interviews were coded using an inductive open-coding process. In this process, codes were assigned to excerpts which could represent recurring concepts or categories, as described in [Weiss, 1995]. During the coding process 255 unique codes from the data of the first interview and 173 codes from the data of the feedback interview were generated. The software used for coding was MAXQDA[5].

In a next step, quotes which represented the most commonly applied codes were transferred to post-its in order to create an affinity diagram. The affinity diagram revealed the main themes of challenges and practices concerning home-exercises for physiotherapy, and organized the feedback of each instruction method. An image of the completed affinity diagram can be seen in figure 4.3.

4.7.2 Questionnaire Analysis

The questionnaires were filled out by the participants using LimeSurvey[6]. The responses were analyzed using R[7]. The responses to the questions were preprocessed and visualized. For every question item, the feedback concerning each instruction method was juxtaposed in a

[4] www.audiotranskription.de/f4
[5] www.maxqda.de
[6] www.limesurvey.org/de/
[7] www.r-project.org

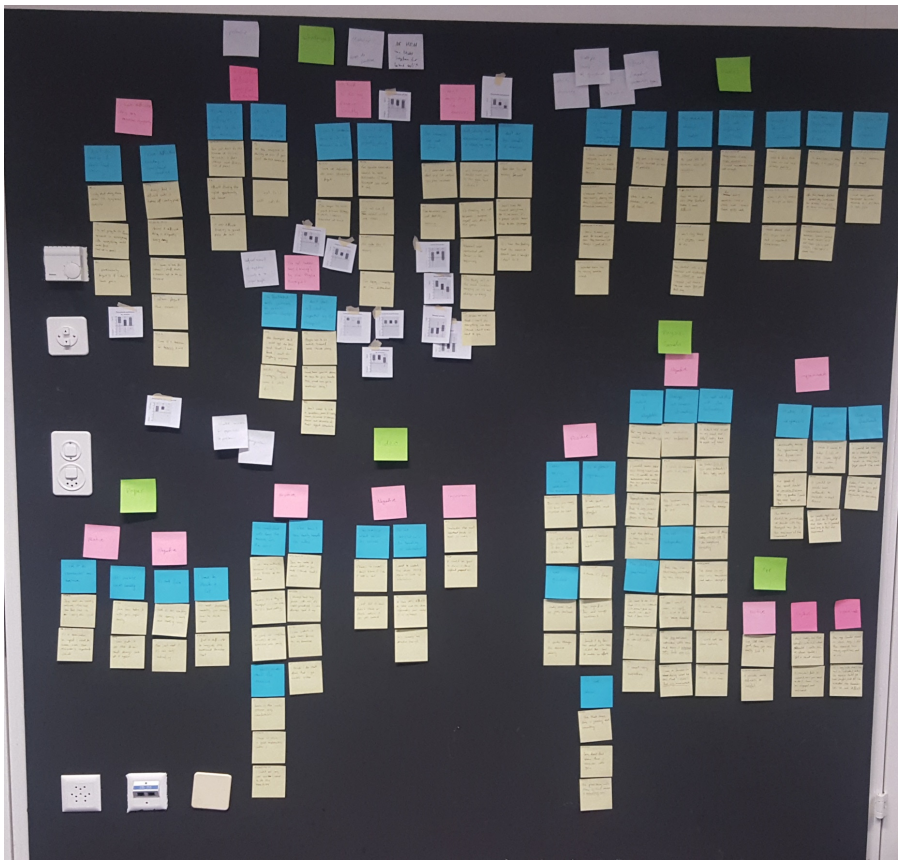


Figure 4.3: Affinity Diagram created in the process of analysing the interview data. Yellow post-its are quotes, blue and red ones are low- and higher-level themes, green ones organize overall topics

graph using three boxplots as shown in figure 5.5 and 5.6. The raw data of the questionnaire responses is provided in appendix G.

The data gathered in the questionnaire was collected for the purpose of illustrating and supporting the findings from the interviews. It was not the goal to achieve statistically significant results, and therefore no statistical analysis on the data was conducted. Due to the limited number of participants, the results do not generalize to the population of physiotherapy patients. The data was analyzed informally to gain a general understanding of the user experience and to draw connections to the insights from the interviews.

4.7.3 Design Implications

The design implications were derived by "walking the affinity wall", a technique described in [Beyer and Holtzblatt, 1997]. The different themes and quotes on the affinity wall were investigated with the goal of finding solutions for the problems at hand. This resulted in a set of design implications in the form of requirements for a physiotherapy coaching system which should addresses the challenges presented on the affinity diagram. Finally, for each of those design implications, the design of the current Physio-Coach was assessed and suggestions for the further development were proposed.

This procedure ensured the direct foundation of the design implications on the generated qualitative data.

Chapter 5

Results

In this chapter, the results of the preliminary evaluation and the laboratory study are presented. First the results of the preliminary evaluation are introduced. Next, the insights gained in the interview on challenges and practices are presented, followed by the outcomes of the EARS. Then, the results of the questionnaire are presented and lastly the outcomes from the feedback interview are explained, in relation to those results of the questionnaire.

5.1 Preliminary Evaluation

There were 62 participants in the preliminary evaluation which were questioned using the questionnaire described in section 4.2 (appendix A). The demographic information collected showed a slightly higher male participation (M: 43, F: 20) and the mean age was 35 (SD: 11).

In general, the outcome shows that the participants felt that doing the exercises with the Physio-Coach was fun, easy to follow and they likely would want to try it at home. The outcomes of the four technology acceptance questions concerning perceived enjoyment, perceived ease of use, perceived usefulness and intention to use are illustrated in figure 5.1. The outcomes were all very positive with medians on 2 (”Agree”) for perceived enjoyment, perceived usefulness and intention to use and on 3 (”Strongly agree”) for perceived ease of use, all in positively framed statements. The responses to perceived ease of use

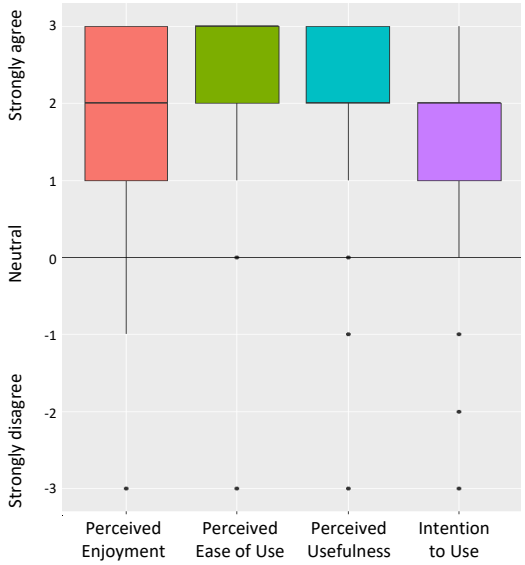


Figure 5.1: Responses on Technology Acceptance [Davis et al., 1989] from participants at Digital Day Switzerland.

and perceived usefulness were very similar, likely due to the question wording which was almost identical: ”I could follow the exercise well” vs. ”It was easy to copy the exercise”, both practically addressed ease of use.

The responses concerning problems in physiotherapy home-exercises and propositions for improvements for the Physio-Coach are illustrated in figures 5.2 and 5.3. The predefined answers usually reached a higher number of votes than themes created by the participants themselves, however some interesting outcomes could be observed.

Concerning problems with physiotherapy exercises (figure 5.2) there were two problems from the predefined answers which reached the highest number of votes, namely 13 each for ”I don’t really know whether the execution is correct” and ”I forget to do the exercises at home”. Another frequent answer was ”Lacking motivation” (N=8) which was not a predefined answer. The outcomes for the question concerning problems can be summarized by the three main themes of correctness, forgetfulness and motivation.

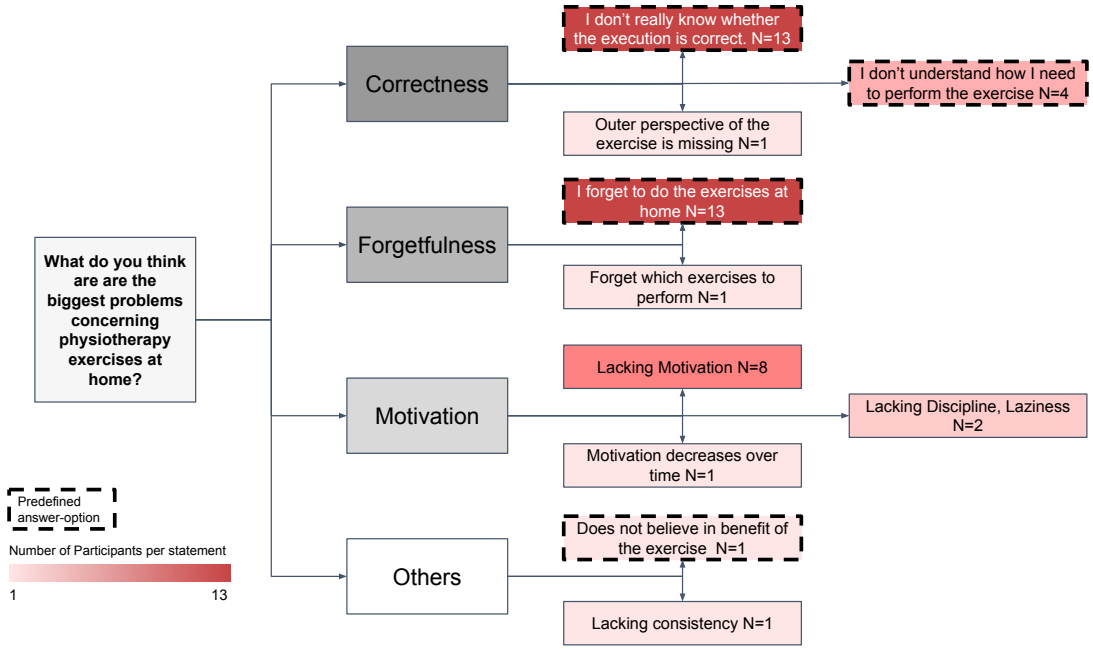


Figure 5.2: Illustrated are problems of participants with physiotherapy experience at the Digital Day Switzerland.

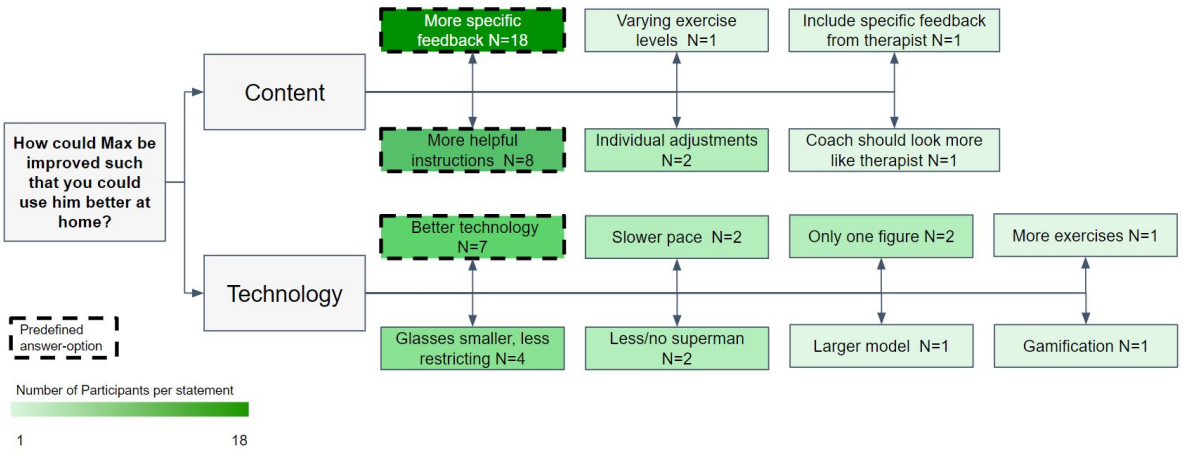


Figure 5.3: Illustrated are improvements proposed by participants with physiotherapy experience at the Digital Day Switzerland after testing the first physiotherapy-coach.

There were several improvements proposed for the first version of the Physio-Coach which were related to either the content or to the technology (figure 5.3). The three predefined answers ”More specific feedback”, ”More helpful instructions” and ”Better technology” reached the highest approval with 18, 8 and 7 votes respectively. Other proposed improvements included smaller glasses, improvement on the virtual character(s), more individual adjustments and feedback.

The proposed improvements for the first version could largely be implemented for the second version of the Physio-Coach. The implemented features were ”More specific feedback”, ”More helpful instructions”, ”Coach should look more like physiotherapist”, ”Only one figure” and ”Less/no superman”. In the second version of the Physio-Coach, the feedback functionality was implemented and more detailed instructions were provided. The two virtual characters were merged into one, where Max is assistant and model simultaneously. He appears less like a super-hero and wears a physiotherapist-like outfit.

5.2 Interview on Challenges & Practices

This section illustrates the results from the first interview in the laboratory study. The different themes which have emerged about the challenges concerning the participant's experience with physiotherapy exercises at home are presented herein. Those challenges are followed by commonly adopted practices, both ordered by the popularity in which they were mentioned by the participants.

5.2.1 Challenges

There was a number of problems patients encountered, related to performing exercises during their physiotherapy. However, it should be mentioned that the patients generally felt that their therapy was going well and their motivation was high. Nevertheless, the following main challenges were often mentioned in the interviews.

Frequency. 12 out of 15 patients had difficulties building a consistent frequency by which they performed their exercises. Reasons for that

were: forgetting to do the exercises (5 participants), missing utensils (4 participants), taking time (3 participants), difficulties starting their routine (2 participants) and lacking discipline (1 participant). Another commonly mentioned challenge concerning frequency was that the exercises are not performed if the patient doesn't have pain (4 participants). *P4: "[...]and then you say, oh I'm not going to do it[exercises] now, because actually I'm fine in daily life, just if I want to go back to sports, I need to do it."*

Accuracy. 10 patients mentioned difficulties performing the exercises correctly. This was usually due to two reasons. Either it was related to the patients forgetting how the exercise is executed in detail: *"The longer the more I want to know details [...] or I have to do it exactly like that and then I can't remember those things at once."* Or that it was particularly challenging to do the exercises accurately by oneself. *P4:"[...] that you really focus on those positions, which is more difficult if you are alone or in front of a mirror because you still can't focus on the same things as if you receive feedback from someone."* Similarly *P11:"The outer view which is kind of missing, you often don't see yourself[...] you don't have a direct feedback or just what you can estimate yourself."*

Enjoyment. Nine participants associated rather negative feelings with the exercises. This included not enjoying the exercises: *P12:"The exercises are just terribly boring"*, as well as feelings of guilt or stress: *P9:"I was annoyed, [...] I should have gone to the gym, but I didn't"* or frustration due to no perceived benefit: *P6:"I don't have the reward every time I do it, because it's a process which takes time to see changes."*

Support. The theme of lacking support by their therapist was mentioned by three participants. This either related to lacking resources of the physiotherapist: *P12:"I'm not going to ask a question even if I really want to, as it would stress them out because of their tight schedule."*, or an insufficient attitude: *P14: "Physiotherapist has to be active himself and think along."*. Lastly frustration with the guidance on activities outside physiotherapy was voiced: *P13: "She [therapist] said I must* not *snowboard, I must* not *inlineskate and I must* not *do this and that and I sat there and thought so basically I can't do anything anymore except lying and standing."*

5.2.2 Practices

The patients' practices concerning home-exercises in physiotherapy are presented herein to provide insights into how physiotherapy is performed by the participants and what were common themes arising. Generally, the interviews revealed that the patients' practices were quite adherent and constituted a successful therapy.

Evolving program. All participant with one exception mentioned that their exercises evolved over time. This could be that they had to perform evolving variations of their exercises, *P7: "Actually, the exercises I just had now were basics, now we can go one step further, and make it a bit more difficult, so I'm gonna do that until next time.[...] it's a replacement in this case because I can already do the previous exercise."* or that their program included different exercises over time. *P12: "We started with 2,3 exercises and then more and more added up until they where so many that they said I should just take the ones which feel good that day."*

Varying place. Participants performed their exercises in various places. Those included home (10 participants), the fitness studio (8 participants), outside (3 participants) or at work (2 participants). Several participants did not enjoy doing their exercises at home or found it difficult to find a suitable place. *P15: "You could do it at home in front of the TV on the carpet or in the living room, but you somehow just don't do it because it seems weird and out of place [...] you want equipped rooms which are already sport-ish."* One participant (P3) mentioned *"[...]for example if you stand somewhere on an escalator you can stretch for a bit and I realized I pick up those elements whenever there is an opportunity in my everyday life."*

Focus. While performing the exercises, 10 patients indicated that they were focusing on the exercise execution. Some commented that they visualized their movement. *P7: "It's mostly a visualization of where am I [...], how is my body, how is the tension, do I have a correct position [...]."* Others were thinking about the therapists instructions. *P4: "Sometimes I think about what the Physiotherapist said about what I need to be careful about and what is important"*. Generally the exercise performance was the main focus, while 5 participants also listened to music and 4 participants sometimes talked to someone.

Motivation. Nine Participants commented that they are motivated to do the exercises. Often they were motivated because they wanted to return back to doing sports. *P4: "I know how it felt when I played handball and my goal is to go back to that place as soon as possible, so that I can play handball again."*. Consequently they performed all of the recommended exercises and repetitions. *P12: "I always do all of them, [...] I want to get healthy again [...] so that I can do the things I like to do, that's why it motivates me to do it."*

Inclusion into routine. Several participants (9) remarked that they included their exercises into their existing routine as much as possible. This could mean an inclusion into their existing fitness or sports routine, *P8: "So I said I train quite often and I would like to integrate it there and so we made sure it's something which is convenient to integrate as a warm-up"* or the patients included the exercises at specific times during their daily routine. *P9: "I always do that in the morning and then shortly before lunch and then at around 3 or 4 [...]."*

Simple exercises. The exercises were often quite simple, as seven participants stated. This could be because of the nature of the exercises, *P3: "The exercises are not that difficult, actually relatively simple from my point of view[...]."* or because the exercises were performed over a longer period of time and thereby known well. *P8: "Mainly because I do lots of the exercises already for a while and I know them quite well[...], if you know them quite well it kind of works automatically I think."*

Repeated treatment. Eight patients were not in Physiotherapy for their first time. Some were returning due to new injuries, *P4:"Also now when I injured the meniscus[...] and then I had this on the shoulder, that was also on prescription from the doctor, and now the last thing was because I broke my arm I ended up in physiotherapy."* others because after their therapy, the symptoms returned. *P8: "I thought it would be better, but then it wasn't better and now I'm back since December."*

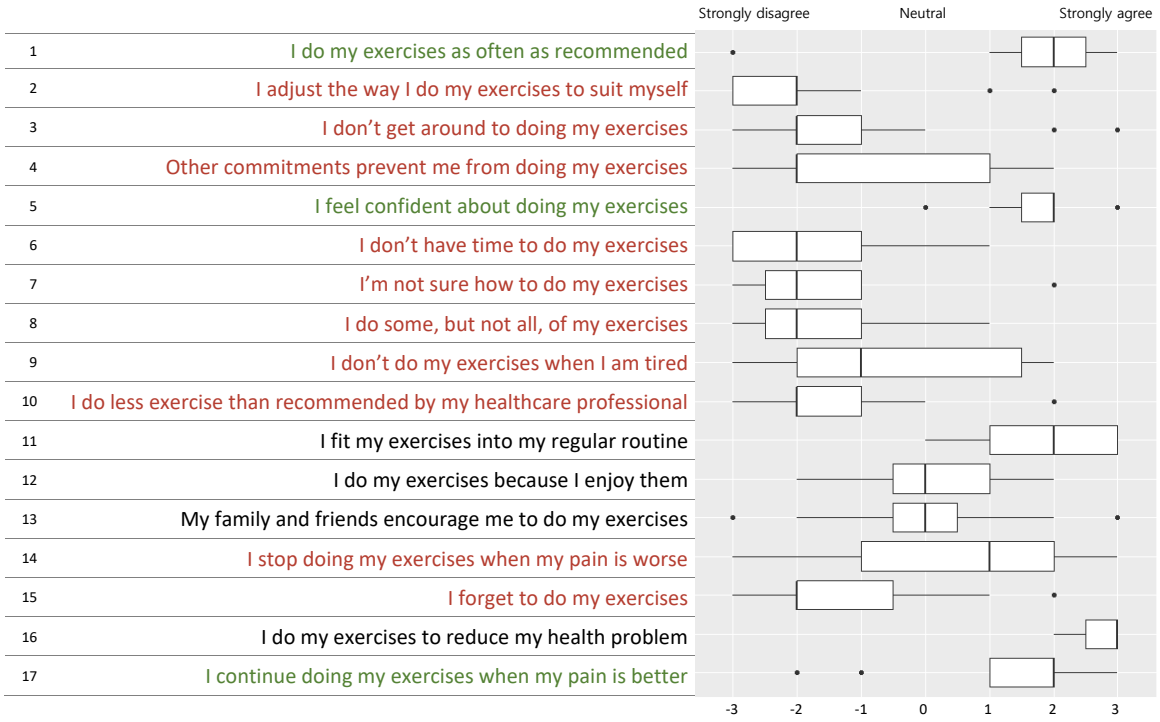


Figure 5.4: Exercise Adherence Rating Scale (EARS) results. Statements which indicate adherent behavior are colored in green, those which indicate non-adherent behavior in red. Neutral Statements are colored black.

5.3 Exercise Adherence Rating Scale

In this section, the responses to the EARS are presented. Figure 5.4 illustrates the distribution of the answers on a 7 point likert-scale.

Generally, it can be said that the participants were agreeing on positively framed statements on adherence and disagreeing on negatively framed statements. Thereby, the participants perception of their adherence seemed to be positive.

The median of the responses to the three positively framed statements concerning frequency (1), confidence (5) and continuity (17) was always on 2, i.e. "Agree". The surveyed patients perceived their exercise performance frequency to be as often as recommended (1), they

were confident about how they performed their exercises (5) and also stated to continue doing their exercises when their pain is better (17).

Similarly, all negatively framed statements, with two exceptions, had their median on -2 i.e. ”Disagree”. Therefore the patients felt that they did not adjust their exercises (2) and they found time and opportunity for their exercises (3,4,6). They knew how to perform their exercises (7), did all of them (8) with a sufficiently high frequency (10) and did not forget to do their exercises (15). The responses to the statement concerning whether the patients do their exercises if they are tired (9) was not as clear with a median on -1 i.e. ”Slightly disagree” and a standard deviation (SD) of 1.9. Another less clear response is related to continuity of exercises after worsening of pain (14) which produced mixed results with a high SD of 2 and a median on 1 i.e. ”Slightly Agree”. The participants also mentioned during the study that they were not sure how to answer the question.

The neutral statements either provoked very positive or neutral responses. Participants agreed with a median of 2 that they included their exercises into their regular routine (11) and even higher agreement was provoked with the statements that patients do their exercises to reduce their health problem (16), with a median on 3 i.e. ”Strongly agree” and a SD of 0.5. The statements concerning doing exercises because they enjoy it (12) and encouragement of family/friends (13) did not show any considerable tendency towards agreement or disagreement.

After inverting the means of the negatively framed statements, the overall mean considering all positively or negatively framed EARS items is 1.7.

5.4 Questionnaire

In this section the results of the questionnaire are presented. This will serve as supporting material to explain the insights from the interviews and to assess certain parameters of the user experience across all instruction methods to enable a more direct comparison. Therefore, the results of the questionnaire are presented before those of the feedback interview, to enable the linking of certain responses to themes in the presentation of the interview’s results.

As the number of participants was low, no statistical analysis was performed on the data and the results do not generalize to the population of physiotherapy patients.

All responses were measured on a 7-item likert-scale coded as ranging from -3 to 3 with varying dimensions as illustrated in figures 5.5 and 5.6. The responses are explained in the following paragraphs.

5.4.1 Technology Acceptance

The Technology Acceptance questions are based on the Technology Acceptance Model [Davis, 1985] as described in chapter 4. The statements assessed the perception of enjoyment, ease of use, usefulness and intention to use of the three instruction methods, and were all measured on a ”Strongly disagree” to ”Strongly agree” scale, except the intention to continuous use question reached from ”Not at all” to ”Very much”.

Perceived enjoyment (figure 5.5 a)) was evaluated by measuring agreement on the statement: *”The [instruction method] was fun to use.”* The responses for the Physio-Coach were most positive with a median on 2, i.e. ”Agree”, followed by the video-instruction (median: 1, i.e. ”Slightly agree”) and lastly the paper-instruction with a median on 0 i.e. ”Neutral” while the interquartile range (IQR) remained on the positive range. Participants therefore perceived the Physio-Coach as most and the paper-instruction as least enjoyable.

Perceived ease of use (figure 5.5 b)) was measured using the statement *”I could understand the [instruction method] very easily.”* While all instructions seemed easily understandable, the median concerning the Physio-Coach (3, ”Strongly agree”) was higher than the one of the other two instructions (2, ”Agree”).

Perceived usefulness as a reminder (figure 5.5 c)) was elicited using the following statement: *”I found the [instruction method] useful to be reminded to do the exercises.”* Also here, the median of the responses to the Physio-Coach (2, i.e. ”Agree”) is higher than those of the other two instructions (1, i.e. ”Slightly agree”).

Perceived usefulness as a motivator (figure 5.5 d)) elicited responses to: *”The [instruction method] motivated me to do the exercises.”* The par-

ticipants perceived the Physio-Coach as most, the video-instruction as second most and the paper-instruction as least motivating, with medians of 2 (”Agree”), 1 (”Slightly agree”) and 0 (”Neutral”) respectively.

The last statement on perceived usefulness (figure 5.5 e)) was *”The [instruction method] helped me to do the exercises correctly.”* The responses for the Physio-Coach and the video-instruction were very similar with a median on 2, i.e. ”Agree” while the paper-instruction evoked less positive responses with a median on 1, i.e. ”Slightly agree”

The statement concerning the intention to continuously use the instruction method (figure 5.5 f)) was phrased as: *”How much would you like to continuously use the [instruction method]?”*. The responses concerning all instruction methods brought about a very similar result with a median on 1, i.e. ”A little”. While the IQR is bigger in both Physio-Coach and video-instruction than in the paper-instruction, in the video-instruction the responses are skewed slightly more towards the positive end.

5.4.2 Task Load Index

As described in section 4.6.2, the two questions taken from the Task Load Index [Hart and Field California Lowell Staveland, 1988] evoked information about mental activity and the degree of frustration when using the instruction methods.

The response scale reached from -3, i.e. ”Very low” to 3, i.e. ”Very high” for both questions.

The question on mental activity (figure 5.5 g)) was asked as: *”How much mental and perceptual activity was required with the [instruction method]?”* The results of the Physio-Coach and the video-instruction were similar with a median on -1, i.e. ”Rather low” while the median of the paper-instruction was on 0, i.e. ”Neutral”.

The degree of frustration (figure 5.5 h)) was elicited using the question: *”How frustrated (insecure, discouraged, stressed versus secure, content, relaxed) did you feel during the execution with the [instruction method]?”* All instruction methods had a median below zero, indicating low frustration. The Physio-Coach and the video-instruction had the same median on -2, i.e. ”low”, while the paper-instruction

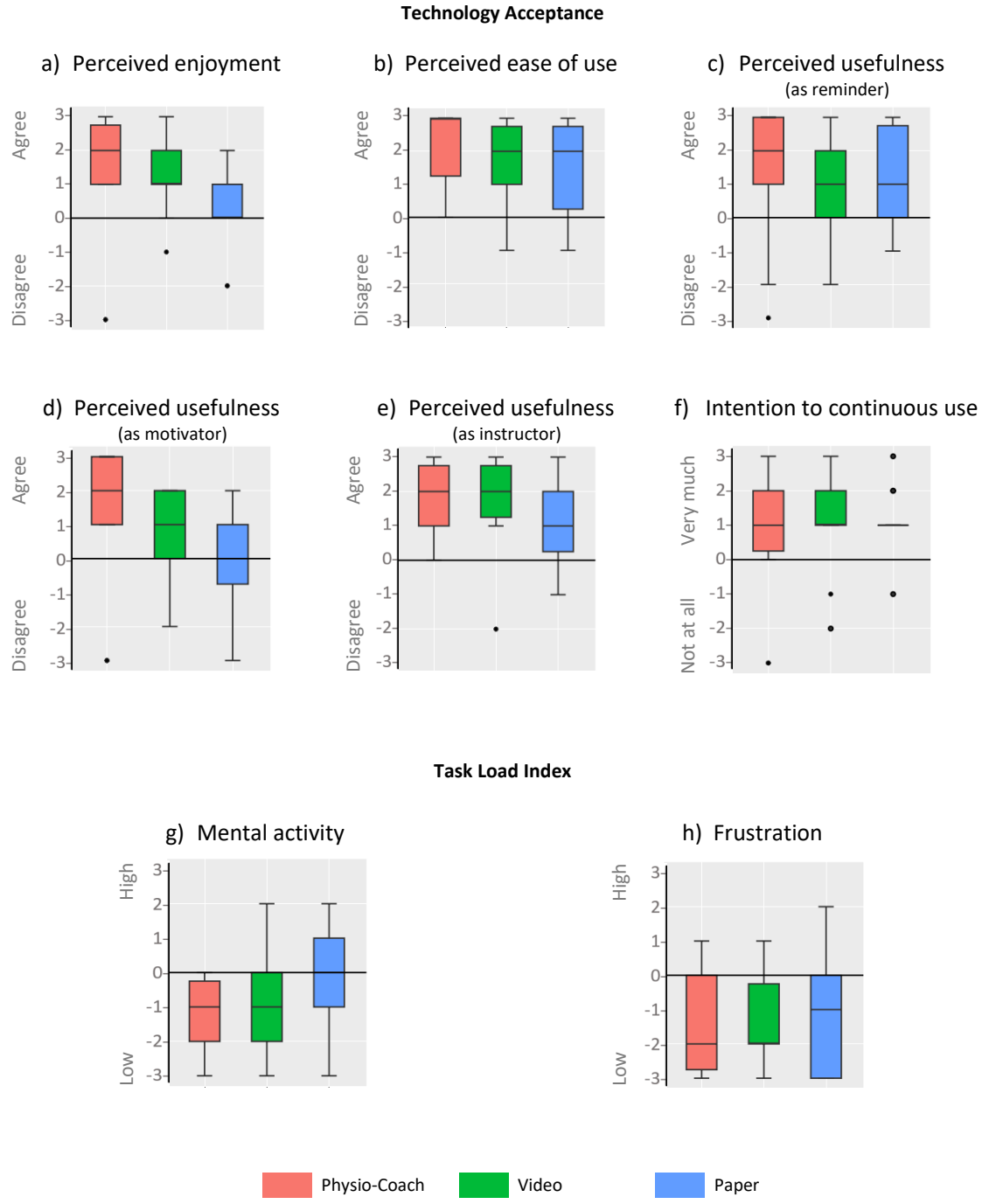


Figure 5.5: Questionnaire results of the questions about Technology Acceptance [Davis et al., 1989] and Task Load Index [Hart and Field California Lowell Staveland, 1988] of the different instruction methods

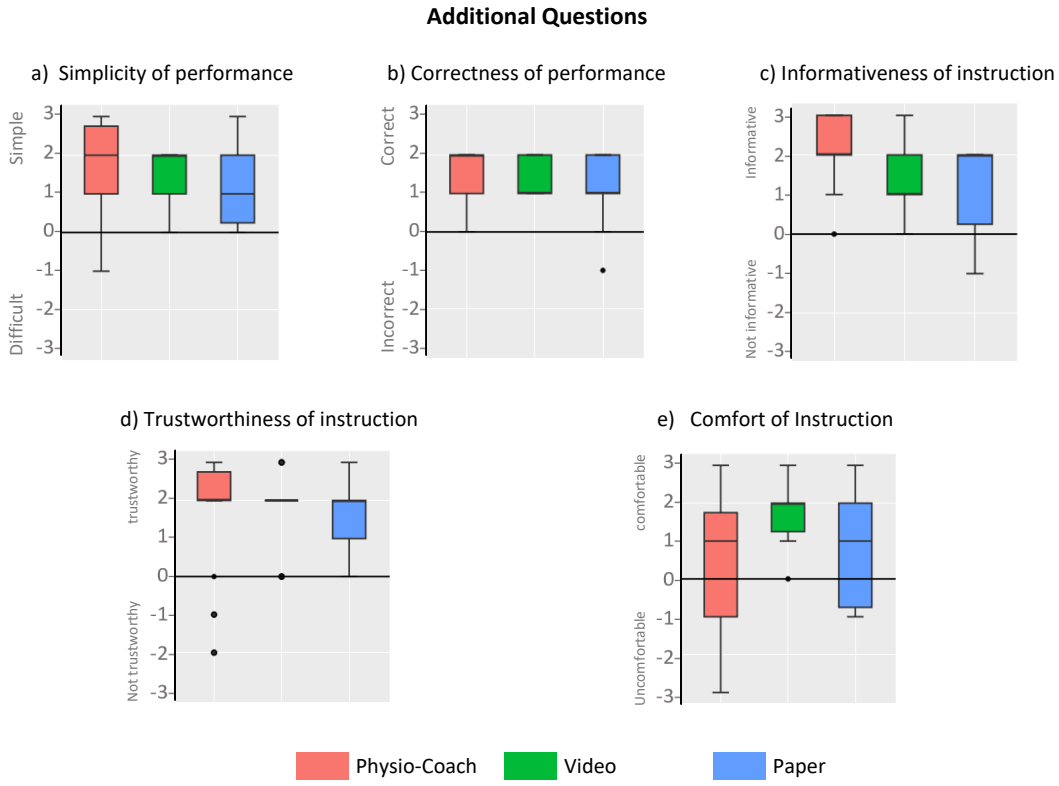


Figure 5.6: Questionnaire results of additional questions concerning the different instruction methods

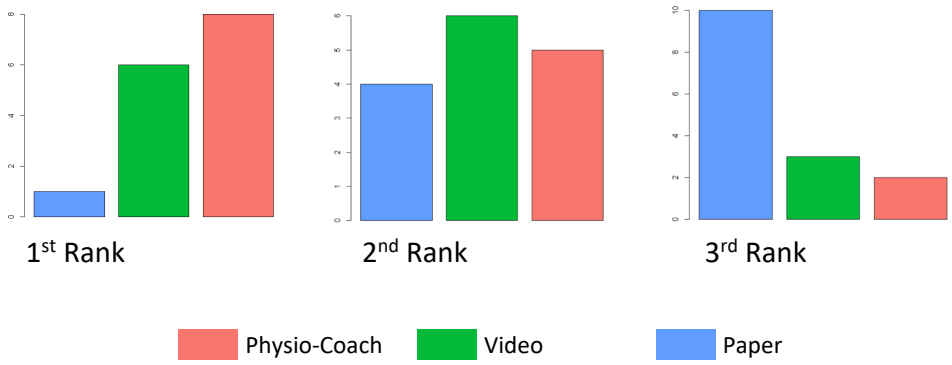


Figure 5.7: Ranking question results

was skewed towards less negative numbers with the median at -1, i.e. ”Rather low”.

It can be stated that the mental activity required, as well as the frustration experiences with all instruction methods was fairly low, when using the Physio-Coach and video-instruction it appeared even lower than when using the paper-instruction.

5.4.3 Additional questions

The responses to the additional questions developed in this work are introduced in the following paragraphs.

The simplicity of performance (figure 5.6 a)) was inquired using the wording: *”How simple/difficult was it to do the exercise?”*. Performing the exercise with each instruction method appeared seemed relatively simple, while the Physio-Coach and video-instruction had a higher median (2, ”Simple”) than the paper-instruction (1, ”Rather simple”).

The correctness of performance (figure 5.6 b)) was elicited through: *”How correct/incorrect do you think you performed the exercise?”*. While the distribution of the responses look very similar across the instruction methods, the Physio-Coach has a higher median (2, ”Correct”) than the video and paper-instruction (1, ”Rather correct”)

The question on the informativeness of the instruction (figure 5.6 c)) was: *”How informative was the [instruction method] in explaining the exercise?”*. While all instruction methods seemed generally informative, the distribution of the answers varied. The physio-coach and the paper-instruction both had their median on 2, i.e. ”Informative”, however the Physio-Coach was skewed slightly more to the higher end of the scale with a smaller IQR than the paper-instruction whose IQR ranges between approximately zero and 2. The video-instruction has the lowest median on 1, i.e. ”Rather informative”.

The instruction’s trustworthiness (figure 5.6 d)) was elicited as follows: *”How trustworthy did you perceive the information provided by the [instruction method]?”*. The responses to this question produced the same median for all instruction methods, which is 2, i.e. ”Trustworthy”. While there are some differences in the IQRs which is more positive in the Physio-Coach, and less positive in the paper-instruction, it

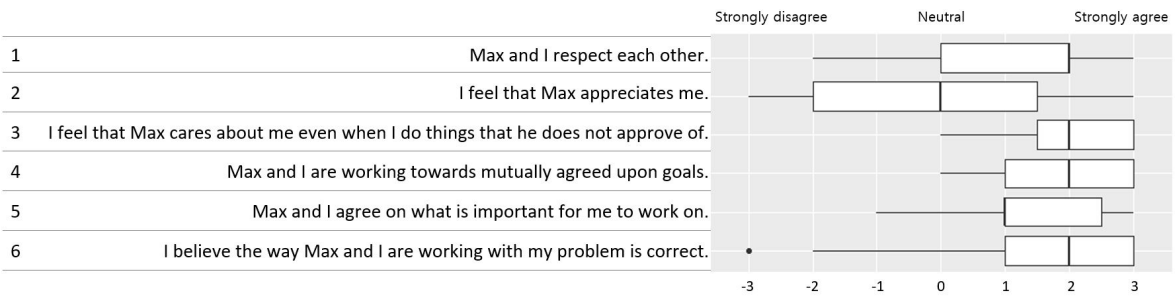


Figure 5.8: Questionnaire results of Session Alliance Inventory concerning interaction with Max in Physio-Coach scenario

can be said that all instructions were perceived similarly trustworthy.

The comfort of the instruction (figure 5.6 e)) was assessed by the question: *"How comfortable was it to do the exercise with the [instruction method]?"*. This question elicited the most positive responses from the video-instruction with a median of 2, i.e. "comfortable", whereas the Physio-Coach and paper-instruction had a median of 1, i.e. "Rather comfortable". The IQR of those two were also larger and the Physio-Coach shows a variability across the whole scale whereas the paper-instruction only covers the range from -1 upward. I can be seen that while the instruction methods all seemed somewhat comfortable, there were some participants who responded differently, especially to the Physio-Coach and to some degree the paper-instruction.

Overall, the instruction methods were perceived quite similarly, however, it can be said that the Physio-Coach seemed to elicit slightly more positive responses concerning simplicity, correctness and informativeness and the video-instruction was perceived as to some extent more comfortable.

Finally, the question prompting the participants to rank the instruction methods according to their preference resulted in a preference for the Physio-Coach, followed by the video-instruction and lastly the paper-instruction. The ranking is illustrated in figure 5.7. The responses written by the participants explaining their choice is provided in appendix G, table G.4. Those responses coincided with the insights of the subsequent interview and are therefore considered in those results presented in section 5.5.

5.4.4 Session Alliance Inventory

Figure 5.8 illustrates the results of the Session Alliance Inventory. The question items assessing the bond with Max (items 1-3) resulted in either positive (item 1, item 3) or neutral responses. The items assessing the tasks and goals (items 4-6) produced slightly more positive responses, with a median of 2 i.e. "Agree" for items 4 and 6 and a median of 1 i.e. "Slightly agree" for question 5. There are not remarkable differences in the responses, except for question 2, where participants did neither agree nor disagree that they felt that Max appreciated them. Overall it can be stated that to a certain degree a working alliance with Max could be established.

5.5 Feedback Interview

The following paragraphs illustrate the insights from the patients' feedback on each instruction method, by first introducing positive aspects, followed by negative aspects about the instruction methods, as well as user-proposed improvements.

Overall, all instruction methods were received well, while one patient commented: *"Basically I was happy about all three of them, because I had the feeling that compared to what I experienced in reality, sometimes there's only an oral explanation or you even have to make an effort to see what the therapist is showing you, so here it was better in all three scenarios."*

5.5.1 Paper-Instruction

Convenient. The paper-instruction was perceived to be very mobile by five participants. *P10: "I find it very convenient, you always have it with you"*. Participants also found it practical to look up information. *P9: "You have information which you can quickly look up, or jump back to the first point before starting, or I could even peek at it while I do them [exercises]."* This theme is in line with the positive responses on perceived ease of use as seen in figure 5.5 b). Interestingly the paper-instruction seemed more informative than video as illustrated in figure 5.6 c) even though all information was the same in all instructions. This could be

because the participants could easily look up information as described previously by patient P9.

Recalls exercise. The paper-instruction seemed useful for five participants to recall what the physiotherapist has said, and thereby also assumed that there should be an existing memory of the therapist explaining the exercise, rather than using it as a first instruction. *P5: "So if the therapist instructs me first and then I look at it three months later, thanks to that [paper-instruction], I remember the exercise again."*

"Like a book". Eight patients criticized that the instruction did not provide an enjoyable experience. *P2: "It's less exciting, it's kind of like you would open a book and read there about how it's done."* They also had difficulty understanding the movement from paper: *P1: "I find it difficult to imagine how I'm supposed to move from the text."* This is also represented in the answers to perceived enjoyment (figure 5.5 a)), where the paper-instruction was perceived least enjoyable as well as required the most mental activity (figure 5.5 g)).

5.5.2 Video-Instruction

Participants appreciated several aspects of the video-instruction.

Easy to understand. It was mentioned by eight participants that it was easy to understand the exercise using the video-instruction: *P2: "I could see very well how I need to do the exercise."* This is also reflected in the positive results for perceived ease of use (figure 5.5 b)) as well as rather low mental activity required for the video-instruction (figure 5.5 g))

Mobile. Three participants commented that they liked the video's mobility: *P11: "I always have the phone with me, that's super practical as I can always look it up."* This could relate to the positive responses concerning comfort of instruction as seen in figure 5.6 e) where video ranked highest.

Authentic. Three participants voiced that they appreciated the exercise-model in the video being a real person and physiotherapist. *P4: "It was very authentic, because it was a real person in the video."* Similarly patient 10: *"I know it's a physiotherapist in the video, so it's trustworthy."* While the video-instruction was perceived as trustworthy by the participants (figure 5.6 d)) there was no great difference to the other instructions.

Information access. While some participants appreciated the handling of information in the video, *P8: "You can make it slower, faster or go back, I think that's nice."* others expressed dissatisfaction. *P6: "It was very difficult to take out the whole information and cache it in my head."* Furthermore, insecurities about whether the execution is correct remained after using the instruction. *P3: "I just did it and didn't think or check if it is still correct,[...] this adds an insecurity whether I really did it correctly."* Those factors could explain the rather low ranking on informativeness of the video instruction, which was lower than both other instruction methods.

Improvements. Participants proposed the following two improvements for the video-instruction. One participant proposed to include the most important points of the instruction as a text-overlay in the video. The other suggestion was to show the exercise from two perspectives, as the video only shows the exercise from one side.

5.5.3 Physio-Coach

Seeing the exercise. The exercise could easily be seen and understood using the Physio-Coach, according to nine participants. Particularly being able to look at the exercise from different perspectives was received well. *P5: "You can see really well how it's supposed to look and it's cool that you can change perspectives."*

Guidance. Nine of the participants appreciated the guidance provided by the Physio-Coach. Specifically, the feedback functionality was received well. *P2: "A very positive aspect is that he corrects you when doing the exercises, which I honestly didn't expect."* Six participants appreciated that someone was joining them during their exercises which

was voiced by *P7: "Then you don't feel alone, you do it together with someone else, I think that's quite motivating."* as well as *P12: "What's great about Max is that someone is motivating you, which makes a very very very* very *big difference"*. This is also reflected in the answers to the questionnaire, where the Physio-Coach was perceived easiest to use and participants reckoned their performance to be best with the Physio-Coach. Furthermore, the coach required low mental activity and was perceived useful as an instructor and as a motivator.

Immobility. A frequently mentioned reason (9 participants) for not intending to use the Physio-Coach is its immobility and burden to carry around, as well as the lacking adaptation capabilities to various exercises. The coach seemed to impose a rather fixed place to perform the exercises and a specific exercise to be carried out, with a given order and timing. *P7: "Honestly, I would never take this thing [Physio-Coach] with me, because it would be too burdensome and heavy, and then it might even break."* Furthermore *P4: "Depending on what exercise I had to do and how I needed to hold my head, I would have found it very burdensome, with those glasses."*. Lastly *P8: "[...] it needs much more time than the other instructions."*

Unfamiliar Interaction. Four patients were not comfortable interacting with the virtual character Max and perceived it to be unaccustomed and strange. This related to the unknown interaction possibilities with the coach on one hand, *P6: "Interaction is unfamiliar, that's certain, there is kind of a barrier there, I'm quite tech-savvy, but it was still new to me in that sense."* on the other hand it related to perceiving the virtual experience as strange and non-human. *P4: "For me it is still kind of outlandish to have this thing on my head and then see this computer-figure in front of me."* Similarly *P9: "The human aspect was kind of missing for me [...] this two-way communication."* Lastly *P15: "Honestly you feel stupid when you reach into the void, and I know I reach into the void, it just adds this insecurity[...]."*

Dissatisfying technology. Participants saw the following software-related issues: There seemed to be a trade-off between Max' distance to the participant and his size. If he was tall enough, the participant did not have to look down constantly, but he was not fully visible due to the limited field of view and confined space in the lab setting. (*P4:*

"I couldn't watch straight I always really had to look down to even see him.") Furthermore, while the feedback was seen as highly valuable there were some trust issues on it's credibility. *P3: "I was insecure whether Max really recognizes if I do everything right, are those really the right corrections[...]."*

Hardware-related dissatisfactions were discomfort and heaviness when wearing the glasses and the limited field of view. *P15: "It was uncomfortable and terribly heavy[...]."* Furthermore *P6: "Concerning interaction, the limited field of view was comparatively blatant, that was a serious point were I had to say now that feels really weird, like constantly watching through binoculars."* Lastly *P12: "It[glasses] didn't hold that well and I didn't really dare to move my head."*. Those concerns could be related to the results in figure 5.6 e) which show that the coach is perceived less comfortable than the video.

Dependency. Some concerns expressed were related to loosing one's independence and difficulty focusing on one's own movement when using the Physio-Coach. *P15: "I don't want to wear an aid[...] it kind of feels like I'm disabled and I'm the slave of this thing."* Similarly *P13: "The step between the instruction with Max and doing it independently feels very big."* Lastly *P13: "I was so focused on doing what he said, that I didn't really feel the movement."*

Great experience vs. childish Eight patients perceived the instruction by the Physio-Coach as a fun and playful experience. *P3: "I found it funny and it was a cool kind of game."* Five of those participants attributed their positive experience to it being the first time using AR-technology. *P12: "Max[Physio-Coach] is very interesting of course, because it's something really new and it's super cool to try that."* The coach was also perceived as the most enjoyable (figure 5.5 a)) and most motivating (figure 5.5 d)) instruction method based on the questionnaire results.

However, four participants did not enjoy how Max interacted and communicated with them. One participant emphasized that he did not emotionally engage with Max and commented on the Physio-Coach: *P1: "It doesn't give me warmth and I don't need it from him [...] it reaches the opposite, you have to see it as what it is, not that, but an instructor which shows some virtual things."* His responses on the Session Alliance Inventory (figure 5.7) were all but one on "Neutral" indicat-

ing the absence of a perceived relationship. Another participant felt the interaction with Max was too childish. *P10: "I think the interaction is somehow better suited for a child, that could be funny, but I would have felt too childish to interact with him, neither was it motivating."*

Useful vs. unnecessary app Nine participants found the accompanying mobile application useful, especially the reminder functionality. *P6: "A reminder would definitely be helpful."* However some patients remarked that the reminder felt like an unwanted obligation. *P10: "It [reminder] feels so imposed, now you need to it, for me I perceive it as an obligation and I am consequently less engaged and motivated compared to when I plan it myself."* The questionnaire showed that the participants found the coach more useful as a reminder (figure 5.5 c)) to do the exercises than the other methods, which is possibly due to the coach's reminder functionality.

Improvements. The participants proposed several improvements for the physiotherapy coach, as well as for the mobile application. One commonly expressed desire was a more adaptable system, where not only the virtual character could be adjusted, but also the speed of the squat execution as well as adjustable movement parameters to account for varying abilities. Another proposition was to use a real person as a virtual character, which as participant four phrased it *"would be much more authentic"*. Additional feedback and reminders during the exercise execution as well as gamification elements such as rewards for regularity and accuracy were also voiced ideas for improvement.

The participants proposed to improve the mobile application by keeping track of the days of adherence and exercise performance with the coach and extend the functionality of the chat-interaction, by eliciting the user's mood or current feeling and enable the adjustment of the exercises' difficulty in the AR-system depending on the patient's state of body and mind.

5.5.4 Summary.

Overall, while the majority of patients enjoyed using the Physio-Coach and greatly valued the feedback functionality, they did not pic-

ture it being the best solution for their own situation. The Physio-Coach seemed to ”oversatisfy” their requirements and was thereby too burdensome to use. As the majority of patients had simple exercises, a dynamic and evolving routine and high motivation, most of them found the video or even the paper-instruction sufficient for their needs.

However, the participants mentioned that they could imagine the Physio-Coach to be very helpful for other people, mainly those with more complex exercises, with less experience exercising or people with less motivation and discipline. Thereby, it can be said that patients found the different instruction methods suitable for their respective use-cases.

Chapter 6

Interpretation & Design Implications

This chapter attempts to combine the insights from the two interviews with the questionnaire's results and existing literature. First, it is elaborated how the challenges and practices found in the first interview can be positioned in the context of prior research. It is then investigated how the different instruction methods can address those aforementioned challenges. Eventually, implications for the development of physiotherapy coaches are provided.

6.1 Interpretation

This section seeks to blend the insights from the interviews, the questionnaire and related work. First, the challenges and practices found in the EARS and the first interviews are revisited and then it is examined how the three instruction methods address those challenges and how they are compatible with the patient's practices.

6.1.1 Challenges & Practices

The findings in this thesis imply that the participants were generally adherent to the therapy regimen in all dimensions of adherence, based

on the EARS and the interview data. The results of the EARS show that there are no large differences in the responses to the EARS items (when inverting negatively framed questions) and most of the question items elicited responses which reflect high adherence. Also, the interviews showed that the participants were in most cases highly motivated and reported a largely sufficient adherence.

This general trend is quite surprising, as related work could show that adherence to physiotherapy was commonly low, as described in chapter 2. The reason for this discrepancy is likely a sample bias, since the number of participants was rather low and the patients agreeing to participate in this study were presumably highly motivated and interested in physiotherapy.

The participant's motivation referred directly to the therapy goal of improving their health condition, which was a recurring theme in the interviews as well as in the EARS. It is represented in the EARS as the strongly agreeing responses to the statement: " I do my exercises to reduce my health problem". To reach their goal, patients were determined to comply in all adherence dimensions, they attach great importance on performing the exercises correctly, frequently and completely. Participants mentioned to not take shortcuts as they mostly completed their whole program with all exercises, sets, and repetitions, which can also be seen in EARS figure 5.4 item 2. Lastly, the patients include the exercises into their existing routine. Those factors all enable the patients to reach their objective of resolving their health issue efficiently.

Even though the participant's goal seemed clear and their motivation high, there remained challenges concerning at-home exercises. While it appeared important to the participants to perform the exercises correctly, several participants admitted that the exercises were likely not as accurate when performed alone, as they would be with the help of their therapist. The patients mainly attributed this difficulty of achieving a high accuracy to a missing outer view and the forgetting of details. This theme is also in line with Palazzo et al.'s work, where the barrier of "Complexity of program" was identified which concerned the patients insecurity about the correctness when performing their exercises [2016].

Similarly, while the exercises were generally performed with a sufficient frequency, many participants admitted there was always room for improvement, and they could have done the exercises more often

and more consistently.

Another remaining challenge was the lacking enjoyment while performing the exercises, which several patients mentioned in the interviews, and which was also reflected to a certain degree in the EARS item 12. This theme was also mentioned in Palazzo et al. as "Burden of exercising" [Palazzo et al., 2016].

An interesting practice found in this thesis and a challenge which is not reflected in Palazzo et al.'s study was that patients performed the exercises in various places and the difficulty of finding a suitable place. The reason for this dissimilarity to other work could be the varying health problems and injuries participants in this thesis were suffering from and their subsequent variety of exercise types which required respectively different settings. Furthermore, the patients often had rather simple exercises which enabled and sometimes even required to be done in various places, whenever possible.

The practices revealed in this thesis reflected a general variety in how patient's perform their exercises, what kind of exercises they perform and where they perform them. This seemed to strongly influence the patients' perception of the different exercise instruction methods, as described in the following section.

6.1.2 Instruction Methods addressing Challenges

In the following paragraphs it is investigated how each instruction method addresses the challenges described in chapter 5.

Overall, each method could at least partly address some of the mentioned challenges. The Physio-Coach could address more challenges than the other two, however, due to its limited mobility it was reckoned to not be easily combined with the patient's existing practices and was thus not always preferred. Table 6.1 illustrates to what degree each instruction addresses the aforementioned challenges and whether the methods are compatible with the patient's practices. Due to space constraints not all combinations are explained in the text.

Paper-Instruction. The paper-instruction was considered mobile and could be used in various locations and allows a flexible integra-

		Paper-instruction	Video-instruction	Physio-coach
Challenges	Frequency			
	Accuracy			
	Enjoyment			
	Support			
Practices	Evolving program			
	Inclusion into routine			
	Varying place			
	Focus			
	Motivation			
	Simple exercises			
	Repeated treatment			

Table 6.1: Degree to what instruction methods address patients' challenges and are compatible with their practices. Green: addressed / compatible, orange: partly addressed / compatible, red: poorly addressed / compatible

tion into diverse routines. Therefore it could be combined with the practice of *"Varying place"*, *"Evolving program"* and *"Inclusion into routine"*.

The paper-instruction was perceived informative and the provided information could be looked up easily, however, it could not provide feedback on the performance and therefore not fully address the challenge of *"Accuracy"*.

The problem of *"Enjoyment"* is not addressed by the paper-instruction, as it was not perceived as enjoyable to use, neither in the interviews nor in the questionnaire (figure 5.5).

It also does not provide any reminder functionality to prevent the patients from forgetting the exercises, thereby the *"Frequency"* problem could not be supported.

Video-Instruction. Similar to the paper-instruction, the video-instruction was perceived mobile and thereby enabled the support of exercises in any place and at any time (*"Varying place"*), but compared to the paper-instruction, the video is saved on a smartphone and is by that even more ready at hand, since the participants mentioned that they almost always carry their smartphone with them.

The difficulty of performing the exercises correctly (*"Accuracy"*) is addressed so far that the video provides comprehensible and illustrative information on the execution, but does not provide feedback on the execution.

The instruction was perceived as somehow enjoyable (*"Enjoyment"*) in the questionnaire (figure 5.5 a)), however, the participants did not comment much on whether they enjoyed to use the instruction.

Physio-Coach. The Physio-Coach received the most positive responses in the questionnaire overall. The items in the questionnaire mostly concerned factors which were related to the challenges *"Accuracy"*, *"Enjoyment"* and *"Frequency"*. Thereby it can be said, in line with the insights from the interviews, that those were the main challenges addressed by the Physio-Coach.

"Accuracy" was addressed by providing easily understandable instructions, a movement visualization from multiple perspectives, as well as performance feedback. Particularly this feedback was perceived as very useful by the patients.

Based on the results of the questionnaire, it can be stated that the Physio-Coach addressed the challenge of *"Enjoyment"*. The questions about perceived enjoyment, perceived usefulness as a motivator, mental activity and frustration were strongly related to the theme of enjoyment and the Physio-Coach evoked (partly the most) positive responses in those questions. However, the answers concerning the comfort of the instruction and the insights from the interviews imply that the Physio-Coach did not seem to provide a very comfortable experience and was thereby less enjoyable.

The challenge of *"Frequency"* could potentially be addressed by the reminder functionality of the mobile application, however, the responses to the reminders were mixed, similar to Palazzo et al.'s work, where the implementation of simple automated reminders was re-

ceived with reservations. [Palazzo et al., 2016]

There has not been any explicit feedback on whether the Physio-Coach could account for lacking *"Support"* of the therapist. As the lacking support was related to unanswered questions and short time during the sessions, the Physio-Coach does not directly address this challenge. It could even further burden the therapists if they need to configure the Physio-Coach for their patients.

Patients mentioned, that the Physio-Coach could not be well combined with their practice of varying exercise places (*"Varying Place"*). The Physio-Coach's limited mobility induces restrictions to it's ability to adjust to the dynamic exercise practice.

6.2 Design Implications

In this section, implications on the development of physiotherapy coaches for home-exercises are introduced. The design implication are presented in the form of recommendations for a general physiotherapy coaching system, which accounts for the challenges and complies with the practices of physiotherapy patients. Those recommendations were derived from this thesis' insights. For each design implication, it is assessed how the Physio-Coach implements the implication and it is suggested how it could do so further.

Informative. In response to the challenge of performing the exercises with a sufficient accuracy, the coaching system should provide information about the exercise execution. As the participants struggled with a lack of support of the physiotherapist, the system should be able to provide complementing information to the physiotherapists explanations.

The Physio-Coach provides information about and illustrates the exercise execution in three dimensions and from multiple perspectives, which was highly valued by the patients. As some patients were interested in knowing details about the exercise execution or sometimes forgot certain minutiae about the exercise, providing access to a big body of knowledge could prove useful, for example linking the coach to online communities or knowledge bases for physiotherapy exer-

cises, where the information by the physiotherapist could be complemented with additional information and background.

Correcting. While the patients perform the exercise, the system should provide feedback about the performance correctness. This addresses the challenge of accuracy and ensures an efficient therapy.

The Physio-Coach's correcting feedback was greatly appreciated by the patients and counteracted the patient's insecurities about their performance. However, there were reservations about the accuracy of the feedback and to positively influence the patients' performance, the feedback should be more reliable. Furthermore, the timing and frequency of corrective inputs should be optimized and adaptable to find the balance between sufficient support and unnecessary or hindering interruptions.

Enjoyable. A problem when performing the exercises was that the participants did not perceive their exercises as enjoyable. Therefore, a coaching system should implement measures to provide a more joyful experience.

The results from the questionnaire and interviews implied that the Physio-Coach provided an enjoyable experience. However, there were reservations about the interaction style and not all patients enjoyed the playful interaction. It is therefore advisable to offer different interaction styles to provide a joyful experience for all patients. For patients who enjoy a game-like approach, for example younger patients [Palazzo et al., 2016], further elements of gamification could be implemented such as rewards for execution accuracy and consistency. For other patients, more lean and serious interaction styles might be suitable.

Engaging. It was difficult for patients to perform their exercises consistently, and therefore a coaching system should support patients in staying engaged over the whole duration of their therapy. Incorporating the exercises into their existing routine helped patients to regularly perform their exercises and thus a coaching system should enable and support this inclusion.

The integrated mobile application enabled a reminder functionality which could support the frequency of exercise execution. Through the use of the virtual agent present in the AR-system as well as in the mobile application, it was possible to establish a working alliance which can also positively influence long-term adherence [Bickmore et al., 2005]. The functionality of the mobile application could be extended by tracking and analyzing adherence and performance data to implement personalized motivation strategies and thereby positively influence the patients engagement.

Flexible. As the patients' exercises and their program was evolving over time, a coaching system should be flexible and allow easily implementable adjustments. This includes allowing different variations of an exercise as well as enable a modifiable program. The exercises' range of motion and level of difficulty should also be configurable to account for different levels of ability. Furthermore, as the participants in this thesis had different levels of knowledge and exercise skills, it is advisable to provide a flexible amount of information and guidance. Lastly, as the challenge of "lacking support" suggests, the systems should allow to be adjusted easily, as the therapists don't have much time to configure such a system.

As of now, the flexibility of the Physio-Coach is limited and improvements in this aspect would pose big challenges. The current implementation of the Physio-Coach is merely a prototype and only one exercise is implemented. To enable a flexible adjustment of the exercises as well as of the exercise program, a base of exercises should be implemented, from which therapists could chose exercises for their patients from. Likely the implementation of a set of exercises which covers all possible variations of physiotherapy exercises is not feasible. More reasonable would be implementing of a set of basic exercises which could be adjusted and parameterized manually by the therapist. Enabling the adjustment of those exercises however, requires an intuitive interface and a complex and modular system. Another approach could be to focus on physiotherapy patients which have to perform few exercises over a long period of time, which do not require frequent alterations, for example patients with chronic illnesses.

Portable. The variety of places the patients were performing their exercises at implies the need for a portable system, which can easily

be transported and enables performing the exercises at any place and at any time.

The Physio-Coach was perceived by some participants as heavy and they would not consider carrying it with them. Even though technological advances are to be expected in the future as head-mounted displays are developing rapidly, the Physio-Coach is currently poorly portable. One possibility is to make the mobile application of the Physio-Coach more independent and include instructional videos and additional information which could serve as the mobile version of the Physio-Coach. This version could support patients with simple exercises, often performed in various places. Those exercises also likely do not require such extensive guidance as offered by AR-system in the Physio-Coach. Concerning the AR-system, it seems more fruitful to focus on patients which have to perform complex exercises which are performed at home or a fixed location. Those patients in turn might not require a highly portable system.

Chapter 7

Conclusion

The goal of this thesis was to investigate how different coaching methods can address the challenges which patients face when performing physiotherapy exercises at home. The first research question sought to gain insights into the challenges and practices of physiotherapy patients. The second research investigated how the Physio-Coach and a paper- and video-based instruction addressed the physiotherapy patients' challenges concerning home-exercises.

Thereby, this thesis attempted to address the problem of insufficient adherence to physiotherapy home-exercise programs as previous literature has shown [Austin et al., 2012, Beinart et al., 2013, Sabate and World Health Organization., 2003].

To address the research questions, a combination of methodologies was implemented. The first research question was addressed by conducting semi-structured interviews and employing an exercise adherence measure from existing research. The second research question was investigated by conducting a user-study where physiotherapy patients tested the instruction methods and provided qualitative feedback through interviews and complementary quantitative feedback through a questionnaire.

The results concerning the first research question suggest that, while patients generally reported a sufficient adherence to the prescribed exercises, they still faced some difficulties. Those were mainly related to the themes of *Frequency*, *Accuracy*, *Enjoyment* and *Support*. While analyzing the patients' common exercise practices, the following patterns

emerged: *Evolving program*, *Varying place*, *Focus*, *Motivation*, *Inclusion into routine*, *Simple exercises* and *Repeated treatment*.

The results of the subsequent user-study imply that the Physio-Coach has the potential to address the challenges of *Frequency*, *Accuracy* and *Enjoyment*, through reminder functionalities, movement feedback, and through providing a playful experience. The Physio-Coach was also perceived as enjoyable by the participants and easy to use in the preliminary evaluation and in the lab-study. However, the Physio-Coach seemed not highly compatible with the patients dynamic exercise practices and seemed to overfulfill the patients requirements. Therefore, several patients preferred the conventional instructions for their own therapeutic situation. Those methods had the advantage of being more mobile. However, they only addressed the challenge of *Accuracy*, and this only partially, as they were similarly informative, but did not provide feedback. This showed that the participants valued a flexible usage of the instruction method more than a supportive method which addressed their challenges but was inflexible.

From the findings above, the following design implications are proposed: a physiotherapy coaching system should be *Informative*, *Correcting*, *Enjoyable*, *Engaging*, *Flexible* and *Portable*. Along those implications, suggestions for the further development of the Physio-Coach were made.

This thesis made several contributions: A list of themes concerning challenges and practices of physiotherapy patients extended and cross-validated existing literature. A preliminary evaluation enabled an understanding of how the first version of the Physio-Coach was generally perceived. Furthermore, a report of the feedback of physiotherapy patients was contributed, combining evidence from qualitative data and numerical measures. Lastly design implications for the further development of physiotherapy coaching systems and the Physio-Coach were presented.

Those contributions support the future development of coaching systems for physiotherapy home-exercises.

Chapter 8

Discussion & Future Work

In this last chapter, the limitations of this thesis and future works are discussed.

The results of this thesis are bound to a set of limitations. The sample of participants was likely biased through the selection process. The recruitment took place in one physiotherapy center and was supported by the physiotherapists who encouraged their patients to participate in the study. The resulting participants were presumably more motivated and interested in physiotherapy than the greater population of physiotherapy patients.

Furthermore, only physiotherapy patients were consulted in this thesis, and the therapists' viewpoint on the instruction methods was not considered. As all those instruction methods require the active creation or configuration of the therapists, their view is a crucial aspect worth further attention in order to create a physiotherapy system which is useful in a real-world setting. This perspective is considered in a master's thesis which is conducted at the time of writing in the context of the CDHI's project.

In addition, while in the user-study measures to assess the exercise execution accuracy were collected, the assessment of those were out of the scope of this thesis. It would be greatly interesting to investigate whether the instruction methods have an effect on the exercise performance. Through this assessment valuable insights could be drawn from complementing the patient's perception presented in this thesis with an objective performance measure. The assessment of these

performance measures is planned in future work within the project at CDHI.

Another limitation is that the feedback of the participants on the instruction methods was based on a one-time use in a laboratory setting, which does not translate fully into their real-life experience and long-time usage. Additionally, as it was the first time for the majority of the participants to use an AR-system, the feedback on the Physio-Coach could have been biased by the sensation of novelty. Lastly, whether the coaching methods could address the challenge of *Frequency* could only be assessed speculatively. To account for the aforementioned limitations, a long-term study could provide valuable learnings about the adoption and perception of the instruction methods in a more realistic setting.

Lastly, while in this work only the further development of the Physio-Coach is discussed, it would be interesting to investigate how other currently common instruction methods could be improved to better address and be united with the patient's challenges and practices.

Being aware of the limitations that restrict the generalizability of this thesis' results, through the thorough investigation of the physiotherapy patients' challenges, practices and feedback, this thesis could reveal that the Physio-Coach can address several challenges of physiotherapy patients. It also revealed the value of considering the specific exercise practices of patients to enable the creation of a system which is applicable in a real-world setting. These findings contribute to a better understanding of the possibilities and the potential of digital and conventional physiotherapy coaching systems and thereby contribute to leveraging physiotherapy to the new digital age.

Appendix A

Preliminary Evaluation Questionnaire (German)

In the following pages, the questionnaire used in the preliminary evaluation is presented in its original form in German.

Max Physiocoach - Umfrage Digital Day

In dieser Umfrage sind 19 Fragen enthalten.

Wer führt das Interview? *

❗ Bitte wählen Sie eine der folgenden Antworten:
Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Valérie
◯ Leo

Darf ich Ihnen daher ein paar Fragen zu Max, dem Physiocoach, stellen?◘

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Ihr Geschlecht? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((willToParticipate.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/234) == "Y"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ weiblich
◯ männlich

Wie alt sind Sie?

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '2 [willToParticipate]' (Darf ich Ihnen daher ein paar Fragen zu Max, dem Physiocoach, stellen?◘)

❗ Ihre Antwort muss zwischen 3 und 120 liegen.
❗ In diesem Feld darf nur ein ganzzahliger Wert eingetragen werden.
Bitte geben Sie Ihre Antwort hier ein:

Jahre

Arbeiten sie tagsüber in einem Büro? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((willToParticipate.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/234) == "Y"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Tragen Sie eine Brille? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((willToParticipate.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/234) == "Y"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Haben sie Prescription-Glasses während der Demo benutzt? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '6 [glasses]' (Tragen Sie eine Brille?)

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Haben Sie schon einmal eine Mixed Reality/VR/AR Technologie (zb. Swiss Peaks App, VR HEadset der Sony Playstation, Oculus oder die Hololens von Microsoft) genutzt? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '2 [willToParticipate]' (Darf ich Ihnen daher ein paar Fragen zu Max, dem Physiocoach, stellen?◘)

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Welche Technologie haben Sie zu welchem Zweck benutzt?

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '8 [technologyUse]' (Haben Sie schon einmal eine Mixed Reality/VR/AR Technologie (zb. Swiss Peaks App, VR HEadset der Sony Playstation, Oculus oder die Hololens von Microsoft) genutzt?)

Bitte geben Sie Ihre Antwort hier ein:

Bitte beurteilen Sie folgende Aussagen von stimme ganz und gar nicht zu (1) bis stimme vollkommen zu (7). *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((willToParticipate.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/234) == "Y"))

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

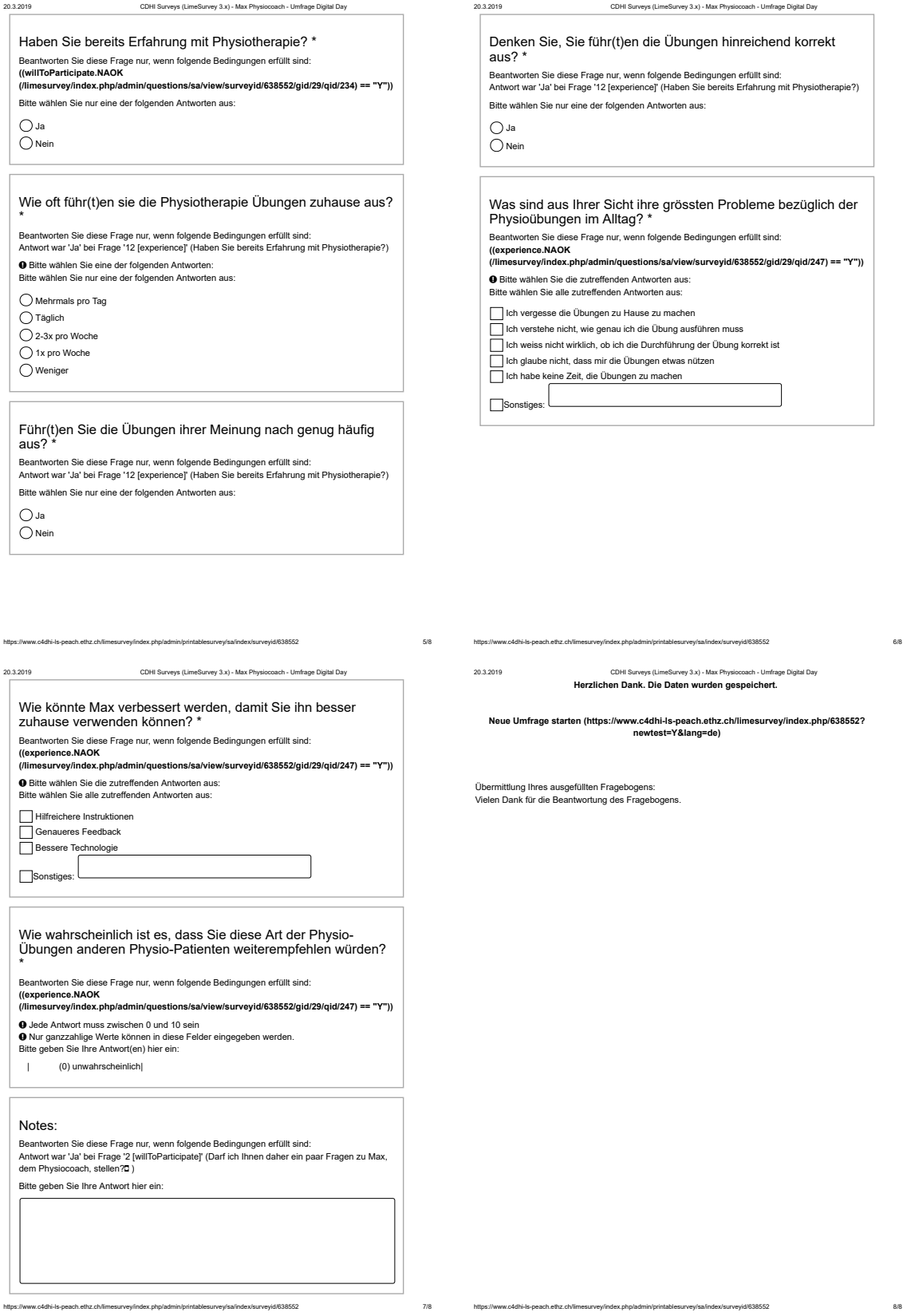
	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Mir hat die Übung mit Max Spass gemacht.	◯	◯	◯	◯	◯	◯	◯
Ich konnte der Übung gut folgen.	◯	◯	◯	◯	◯	◯	◯
Es war einfach die Übung nachzumachen.	◯	◯	◯	◯	◯	◯	◯
Falls ich diese Übung im Rahmen einer Physiotherapie machen müsste, würde ich diese Art der Hologramm-Übung gerne bei mir zu Hause nutzen.	◯	◯	◯	◯	◯	◯	◯

Haben Sie schon Erfahrung mit dem Squat (Kniebeuge)? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '2 [willToParticipate]' (Darf ich Ihnen daher ein paar Fragen zu Max, dem Physiocoach, stellen?◘)

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein



20.3.2019 CDHI Surveys (LimeSurvey 3.x) - Max Physiocoach - Umfrage Digital Day

Haben Sie bereits Erfahrung mit Physiotherapie? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((willToParticipate.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/234) == "Y"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Wie oft führ(t)en sie die Physiotherapie Übungen zuhause aus? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '12 [experience]' (Haben Sie bereits Erfahrung mit Physiotherapie?)

❗ Bitte wählen Sie eine der folgenden Antworten:
Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Mehrmals pro Tag
◯ Täglich
◯ 2-3x pro Woche
◯ 1x pro Woche
◯ Weniger

Führ(t)en Sie die Übungen ihrer Meinung nach genug häufig aus? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '12 [experience]' (Haben Sie bereits Erfahrung mit Physiotherapie?)

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

https://www.c4dhi-ls-peach.ethz.ch/limesurvey/index.php/admin/printablesurvey/sa/index/surveyid/638552 5/8

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Denken Sie, Sie führ(t)en die Übungen hinreichend korrekt aus? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '12 [experience]' (Haben Sie bereits Erfahrung mit Physiotherapie?)

Bitte wählen Sie nur eine der folgenden Antworten aus:

◯ Ja
◯ Nein

Was sind aus Ihrer Sicht ihre grössten Probleme bezüglich der Physioübungen im Alltag? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((experience.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/247) == "Y"))

❗ Bitte wählen Sie die zutreffenden Antworten aus:
Bitte wählen Sie alle zutreffenden Antworten aus:

☐ Ich vergesse die Übungen zu Hause zu machen
☐ Ich verstehe nicht, wie genau ich die Übung ausführen muss
☐ Ich weiss nicht wirklich, ob ich die Durchführung der Übung korrekt ist
☐ Ich glaube nicht, dass mir die Übungen etwas nützen
☐ Ich habe keine Zeit, die Übungen zu machen
☐ Sonstiges: _____

https://www.c4dhi-ls-peach.ethz.ch/limesurvey/index.php/admin/printablesurvey/sa/index/surveyid/638552 6/8

20.3.2019 CDHI Surveys (LimeSurvey 3.x) - Max Physiocoach - Umfrage Digital Day

Wie könnte Max verbessert werden, damit Sie ihn besser zuhause verwenden können? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((experience.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/247) == "Y"))

❗ Bitte wählen Sie die zutreffenden Antworten aus:
Bitte wählen Sie alle zutreffenden Antworten aus:

☐ Hilfreichere Instruktionen
☐ Genaueres Feedback
☐ Bessere Technologie
☐ Sonstiges: _____

Wie wahrscheinlich ist es, dass Sie diese Art der Physio-Übungen anderen Physio-Patienten weiterempfehlen würden? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
((experience.NAOK (/limesurvey/index.php/admin/questions/sa/view/surveyid/638552/gid/29/qid/247) == "Y"))

❗ Jede Antwort muss zwischen 0 und 10 sein
❗ Nur ganzzahlige Werte können in diese Felder eingegeben werden.
Bitte geben Sie Ihre Antwort(en) hier ein:

| (0) unwahrscheinlich|

Notes:

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
Antwort war 'Ja' bei Frage '2 [willToParticipate]' (Darf ich Ihnen daher ein paar Fragen zu Max, dem Physiocoach, stellen?◘)

Bitte geben Sie Ihre Antwort hier ein:

https://www.c4dhi-ls-peach.ethz.ch/limesurvey/index.php/admin/printablesurvey/sa/index/surveyid/638552 7/8

20.3.2019 CDHI Surveys (LimeSurvey 3.x) - Max Physiocoach - Umfrage Digital Day

Herzlichen Dank. Die Daten wurden gespeichert.

Neue Umfrage starten (https://www.c4dhi-ls-peach.ethz.ch/limesurvey/index.php/638552?newtest=Y&lang=de)

Übermittlung Ihres ausgefüllten Fragebogens:
Vielen Dank für die Beantwortung des Fragebogens.

https://www.c4dhi-ls-peach.ethz.ch/limesurvey/index.php/admin/printablesurvey/sa/index/surveyid/638552 8/8

Figure A.1: Questionnaire preliminary evaluation

Appendix B

Interview Guides (German)

Interview on Challenges and Practices. Introduction: "Die Studie ist eine Kollaboration des Centers für digitale Gesundheitsinterventionen der ETH, der Uni Zürich und der Uni St. Gallen, wo wir gerne herausfinden möchten, wie wir Physiotherapie Patienten bei den Übungen zuhause behilflich sein können mit einem digitalen Assistenten. Deswegen ist es am besten, wenn Sie mir möglichst detailliert von Ihren Erfahrungen mit Physiotherapie und den Übungen zuhause erzählen, damit wir zusammen interessante Informationen gewinnen können, wie Leute zuhause Physiotherapie machen. Am Besten sind jeweils spezifische Anekdoten über Ihre Erlebnisse."

- Können Sie mir erzählen wie Sie mit Physiotherapie begonnen haben?
- (Wie oft gehen Sie in die Physiotherapie?)
- Können Sie mich Schritt für Schritt durch die letzte Physiotherapie Session mit (Therapeut Name) führen?
- Wie hat der Therapeut Sie über die Übungen für Zuhause informiert?
- Nach dieser Session gingen Sie nach Hause und... wann hast du die Übungen gemacht?
- Können Sie mit mir das letzte Mal, als sie die Physioübungen gemacht haben, durchgehen?
- Wenn Sie die Übungen machen, gibt es etwas Anderes was Sie gleichzeitig machen?
- Was ging Ihnen durch den Kopf als Sie die Übungen gemacht haben?
- Können Sie mir über ein Erlebnis erzählen, bei welchem es besonders schwierig oder problematisch war die Übung auszuführen?

- Können sie mir detailliert erzählen, was passiert ist?
- Gibt es etwas, was Ihnen speziell gefallen hat oder Sie nicht mochten an den Übungen?
- Wenn Sie die Übungen machen, was tun Sie um sich zu motivieren?
- Was denken Sie über die Häufigkeit mit welcher du die Übungen machst?
- Machen Sie etwas um Sie daran zu erinnern, die Übungen zu machen?
- Vergessen Sie manchmal einen Tag? Wenn ja was tun Sie dann?
- Was haben Sie für ein Gefühl zur Korrektheit der Übungen?
- Was denken Sie über die Geschwindigkeit mit welcher Sie die Übungen machen?
- Was denken Sie über die Anzahl Repetitionen, welche sie pro Übung machen?
- Gibt es Übungen, die Sie überspringen? Welche sind das?
- Was denken Sie, wie der Therapeut über die Korrektheit ihrer Übungen denkt?
- Was denken Sie sind Gründe weshalb Sie die Übungen nicht korrekt ausführen?
- Wie finden sie es, Übungen zuhause zu machen?
- Haben sie das Gefühl, die Übungen zu machen hilft Ihnen?
- Was für Erfahrungen haben sie generell mit Fitness oder Kraftübungen?
- Wie kombinieren Sie Physiotherapieübungen mit Ihrer sonstigen Fitnessroutine?

Feedback Interview. Introduction: "In diesem Teil geht es darum herauszufinden, wie sie die verschiedenen Instruktionen erlebt haben und wie diese die Probleme welche wir vorher diskutierten adressieren. Ausserdem interessiert uns wie der Physio-Coach verbessert werden kann um die Probleme besser zu adressieren."

- Wie haben Sie die Video/Papier/Physio-Coach Instruktion erlebt?
- Welche hat Ihnen am Besten gefallen und wieso?
- Wie denken Sie adressieren die Video/Papier/Physio-Coach Instruktion die vorher besprochenen Probleme?
- Haben sie Ideen oder Vorschläge wie der Physio-Coach verbessert werden könnte?

Appendix C

Physiotherapist Telephone Survey

In this appendix, the notes from the telephone survey with physiotherapists in Switzerland are provided.

Physiotherapy	Place	Methods	Most popular
Hirslanden Im Park	Zürich	Hand-written stick-figures, oral, Video or Photo	Hand-written stick-figures
Physio Ruth Horber	Zürich	Oral or written down, record patient while they do exercises for later reference	Hand-written stick-figures, phone video
Schulthess Klinik	Zürich	Stationary: Flyers with picture and description Ambulant: Either phone video with description, stick figure, print-out or oral	Brochure, phone video, Hand-written stick-figures
Institut für Physiotherapie Zürichsee	Wädenswil	First oral, then description with stick-figures and sometimes patients take photos	Hand-written stick-figures
Physio Heiniger	Zürich	Stick figures, photos/videos with phone of patients, each 50%	Hand-written stick-figures, photo/videos
MTC Pieter Keulen	Emmenbrücke	Paper with description and pictures, also references to online-blog	(small) Brochure
Physio Balance Anita Längin	Therwil	Oral, (humorous), very seldomly stick-figures or brochures	Oral
Physio/Fitness Ybrig	Unteriberg	App Sophy-app with videos, otherwise textual	Sophy-app
Spital Aarau Physio	Aarau	Oral, young people record with their phone, certain exercises are combined on computer and printed, for certain back-problems there are brochures	Oral, print-out
Physimone	Wildegg	Patients write it down in their own language and manner	Patient-made stick-figures
Applied Health Care	Bern	Video, youtube link, sometimes hand-written	Video
Sonja Romer Physio	Gross	Stick-figures or oral	Hand-written stick-figures
Physio Mühlematter	Winterthur	Oral or stick-figures written down together with patients	Oral, stick-figures
Physio Impuls	Thun	oral, mostly video or photo on phone of patient	Phone video

Table C.1: Notes from telephone survey with physiotherapists

Appendix D

Recruitment Flyer (German)

Valérie Erb
Bachelor-Studentin
Universität Zürich

Sven Witjes
Physiotherapeut und
Geschäftsführer
Applied Health Care Bern

Die Studienarbeit von Valérie Erb wird betreut durch:

Prof. Dr. **Tobias Kowatsch**
Direktor des Zentrums für digitale Gesundheitsinterventionen der ETH Zürich und Universität St.Gallen sowie Assistenzprofessor für digitales Gesundheitswesen der Universität St.Gallen
tkowatsch@ethz.ch

sowie

Prof. Dr. **Elaine Huang**
Direktorin des People and Computing Labors und Professorin für Mensch-Maschine Interaktion der Universität Zürich

Ziel der Studie «**Physiotherapie der Zukunft**» ist es, Ihre Erfahrung mit Physio-Übungen zu Hause zu nutzen um neue Formen der Physiotherapie zu entwickeln. Sie selbst lernen dabei auch neue technische Möglichkeiten der Physiotherapie kennen.

Teilnahmevoraussetzung

- Sie sind 18 Jahre alt oder älter
- Sie verfügen über gute Deutsch-Kenntnisse
- Sie sind in Physiotherapie und haben mindestens drei Sitzungen hinter sich
- Sie haben die Kniebeuge noch nicht als Physiotherapie Übung gemacht
- Sie sind in der körperlichen Verfassung die Kniebeuge auszuführen
- Normale Hör- und Sehfähigkeit oder Kontaktlinsen
- Bereitschaft, 1 Stunde Ihrer Zeit zu investieren um an der Studie in der Applied Health Care Praxis in Bern teilzunehmen

Als Teilnahmeentschädigung erhalten Sie 50 CHF.

Weitere Informationen zur Studie und Teilnahme finden Sie über folgenden Link:
www.c4dhi.org/physio

Eine Studie des Zentrums für digitale Gesundheitsinterventionen der ETH Zürich und Universität St.Gallen in Zusammenarbeit mit der Universität Zürich sowie Applied Heath Care Bern. Die Studie wird durch Eigenmittel der Studienpartner sowie der CSS Versicherung finanziert.

ETH zürich · Universität Zürich[UZH] · Applied Health Care · Universität St.Gallen

Figure D.1: Flyer used to recruit the participants for the laboratory study

Appendix E

Consent Form (German)

The consent form (in German) which the participants signed before taking part in the laboratory study is provided on the following page.

Einverständniserklärung Studienteilnehmer

⇒ Bitte lesen Sie dieses Formular sorgfältig durch.
⇒ Bitte kontaktieren Sie den Untersucher oder Ihre Kontaktperson, wenn Sie etwas nicht verstehen oder etwas wissen möchten

Titel der Studie:	Physiotherapie der Zukunft
Durchführungsort der Studie:	Applied Health Care, Bern
Untersucher (Name und Vorname):	**Kowatsch, Tobias**
Patient/in (Name und Vorname):	

⇒ Ich nehme an dieser Studie freiwillig teil und kann jederzeit ohne Angabe von Gründen meine Zustimmung zur Teilnahme widerrufen, ohne dass mir Nachteile entstehen.

⇒ Ich wurde schriftlich und mündlich über die Ziele, den Ablauf der Studie, über die zu erwartenden Wirkungen, über mögliche Vor- und Nachteile sowie über eventuelle Risiken informiert.

⇒ Ich habe das Informationsblatt zur Studie gelesen. Fragen dazu wurden mir gut beantwortet. Ich kann das Informationsblatt behalten und ich erhalte eine Kopie dieser Einverständniserklärung.

⇒ Ich hatte genügend Zeit, um meine Entscheidung zu treffen.

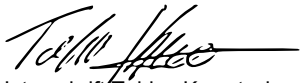
⇒ Ich bestätige mit meiner Unterschrift, dass ich die im Informationsblatt genannten Bedingungen für die Studienteilnahme erfüllen.

⇒ Ich bin darüber informiert, dass die allgemeine Haftpflichtversicherung der ETH Zürich (Police Nr. 30/4.078.362 der Basler Versicherung AG) nur Gesundheitsschäden deckt, die in direktem Zusammenhang mit der Studie entstehen und auf nachweisliches Verschulden der ETH Zürich zurückzuführen sind. Darüber hinaus liegt die Unfall-/Kranken-versicherung (z.B. für die Hin- und Rückreise) meiner Verantwortung.

⇒ Ich bin einverstanden, dass das Studienteam und Mitglieder der Ethikkommission zu Prüf- und Kontrollzwecken meine Daten einsehen dürfen, jedoch unter sehr strenger Einhaltung der Vertraulichkeit.

⇒ Ich bin mir bewusst, dass während der Studie die im Informationsblatt genannten Anforderungen und Einschränkungen einzuhalten sind.

⇒ Ich bin einverstanden, dass meine anonymisierten Daten, entsprechend dem Grundsatz des Schweizer Nationalfonds zum Umgang mit Forschungsdaten, veröffentlicht werden dürfen.

Ort, Datum	Unterschrift Patient/in
Zürich, 24.01.2019	
Ort, Datum	Unterschrift Tobias Kowatsch

Protokoll-Version 2, 22. Januar 2019

Figure E.1: Consent form for participants in the lab study

Appendix F

Questionnaire (German)

In the following pages, the questionnaire of the laboratory study is presented in its original form in German.

Teil A: EARS Exercise Adherence Rating Scale

A1. Patient's Name

A2. Was ist die erste Methode?

- ☐ Paper
- ☐ Video
- ☐ Virtueller Coach

A3. Was ist die zweite Methode?

- ☐ Paper
- ☐ Video
- ☐ Virtueller Coach

A4. Was ist die dritte Methode?

- ☐ Paper
- ☐ Video
- ☐ Virtueller Coach

A5. Bitte beurteilen Sie folgende Aussagen von stimme ganz und gar nicht zu (1) bis stimme vollkommen zu (7).

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Ich mache meine Übungen so oft wie empfohlen.	☐	☐	☐	☐	☐	☐	☐
Ich ändere meine Übungen ab, so dass sie mir passen.	☐	☐	☐	☐	☐	☐	☐
Ich komme nicht dazu, meine Übungen zu machen.	☐	☐	☐	☐	☐	☐	☐
Andere Verpflichtungen halten mich davon ab, die Übungen zu machen.	☐	☐	☐	☐	☐	☐	☐
Ich fühle mich sicher, meine Übungen richtig zu machen.	☐	☐	☐	☐	☐	☐	☐
Ich habe keine Zeit meine Übungen zu machen.	☐	☐	☐	☐	☐	☐	☐
Ich bin mir nicht sicher wie ich meine Übungen machen muss.	☐	☐	☐	☐	☐	☐	☐
Ich mache manche, aber nicht alle meiner Übungen.	☐	☐	☐	☐	☐	☐	☐
Ich mache meine Übungen nicht, wenn ich müde bin.	☐	☐	☐	☐	☐	☐	☐

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Ich mache weniger Übungen als von meinem Therapeuten empfohlen.	☐	☐	☐	☐	☐	☐	☐
Ich baue meine Übungen in meine reguläre Routine ein.	☐	☐	☐	☐	☐	☐	☐
Ich mache meine Übungen, weil sie mir Spass machen.	☐	☐	☐	☐	☐	☐	☐
Meine Familie und Freunde ermutigen mich meine Übungen zu machen.	☐	☐	☐	☐	☐	☐	☐
Ich höre auf meine Übungen zu machen, wenn mein Schmerz schlimmer wird.	☐	☐	☐	☐	☐	☐	☐
Ich vergesse es, meine Übungen zu machen.	☐	☐	☐	☐	☐	☐	☐
Ich mache meine Übungen um meine gesundheitlichen Probleme zu reduzieren.	☐	☐	☐	☐	☐	☐	☐
Wenn meine Schmerzen besser werden mache ich weiterhin meine Übungen.	☐	☐	☐	☐	☐	☐	☐

Teil B: Physio Coach Assessment

Sven hat Ihnen in der Physiotherapie ein Kärtchen mit ihrem Namen, Patientennummer und einem QR Code gegeben, über welchen Sie sich eine App heruntergeladen haben. Auf der App haben Sie Max, ihren virtuellen Physiocoach kennengelernt der Sie heute zuhause an einem definierten Zeitpunkt daran erinnert hat die Übung zu machen und welcher sie dazu motiviert hat die Brille aufzusetzen und die Übungen mit ihm in 3D zu machen.

B1. Wie anstrengend war es die Übung auszuführen?

6 Gar keine Anstrengung ☐
7 ☐
8 ☐
9 Sehr leicht ☐
10 ☐
11 Leicht ☐
12 ☐
13 Etwas schwer ☐
14 ☐
15 Schwer ☐
16 ☐
17 Sehr schwer ☐
18 ☐
19 Extrem schwer ☐
20 Maximale Anstrengung ☐

B2. Bitte beurteilen Sie folgende Aussagen von stimme ganz und gar nicht zu (1) bis stimme vollkommen zu (7).

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Die Art des Coachings hat mir Spass gemacht.	☐	☐	☐	☐	☐	☐	☐
Ich konnte dem Coaching sehr gut folgen.	☐	☐	☐	☐	☐	☐	☐
Ich fand die Art des Coachings nützlich um an die Übungen erinnert zu werden.	☐	☐	☐	☐	☐	☐	☐
Die Art des Coachings hat mich motiviert, die Übungen durchzuführen.	☐	☐	☐	☐	☐	☐	☐
Die Art des Coachings hat mir geholfen, die Übungen richtig durchzuführen.	☐	☐	☐	☐	☐	☐	☐

B3.

	Ganz und gar nicht mehr (- - -)	Nicht mehr (- -)	Eher nicht mehr (-)	Weder noch (0)	Schon etwas (+)	Sehr (++)	In jedem Fall (+++)
Wie sehr würden Sie gerne diese Art des Coachings weiter nutzen?	☐	☐	☐	☐	☐	☐	☐

B4.

	Sehr schwierig(- - -)	Ziemlich schwierig (- -)	Eher schwierig (-)	Neutral (0)	Eher einfach (+)	Ziemlich einfach (++)	Sehr einfach (+++)
Wie einfach/schwierig war es die Übung auszuführen?	☐	☐	☐	☐	☐	☐	☐

B5.

	Absolut falsch(- - -)	Ziemlich falsch (- -)	Eher falsch (-)	Neutral (0)	Eher korrekt (+)	Ziemlich korrekt (++)	Absolut korrekt (+++)
Wie korrekt/falsch haben Sie, ihrer Meinung nach die Übung gemacht?	☐	☐	☐	☐	☐	☐	☐

B6.

	Gar nicht informativ(- - -)	Nicht informativ (- -)	Eher nicht informativ (-)	Neutral (0)	Eher informativ (+)	Ziemlich in formativ(++)	Sehr informativ (+++)
Wie informativ war das Coaching beim Erklären der Übung?	☐	☐	☐	☐	☐	☐	☐

B7.

	Gar nicht vertrauenswürdig(- - -)	Nicht verstrauenswürdig (- -)	Eher nicht verstrauenswürdig (-)	Neutral (0)	Eher verstrauenswürdig (+)	Ziemlich vertrauenswürdig(++)	Sehr verstrauenswürdig (+++)
Wie vertrauenswürdig fanden Sie die Instruktionen des Coachings?	☐	☐	☐	☐	☐	☐	☐

B8.

	Sehr unkomfortabel(- - -)	Ziemlich unkomfortabel (- -)	Eher unkomfortabel (-)	Neutral (0)	Eher komfortabel (+)	Ziemlich komfortabel(++)	Sehr komfortabel (+++)
Wie komfortabel/unkomfortabel war es die Übung mit dem Coaching zu machen?	☐	☐	☐	☐	☐	☐	☐

B9.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie viel geistige Anstrengung war bei der Informationsaufnahme und -verarbeitung erforderlich?	☐	☐	☐	☐	☐	☐	☐

B10.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie hoch war ihre Frustration (unsicher, entmutigt) während der Ausführung mit dem Coaching?	☐	☐	☐	☐	☐	☐	☐

B11.

	Nie(- - -)	Selten(- -)	Gelegentlich (-)	Manchmal(0)	Häufig(+)	Sehr häufig(++)	Immer(+++)
Max und ich respektieren einander.	☐	☐	☐	☐	☐	☐	☐
Ich habe das Gefühl, dass Max mich schätzt.	☐	☐	☐	☐	☐	☐	☐

	Nie(- - -)	Selten(- -)	Gelegentlich (-)	Manchmal(0)	Häufig(+)	Sehr häufig(++)	Immer(+++)
Ich glaube, dass Max zu mir steht, auch wenn ich etwas mache, was Max nicht gut findet.	☐	☐	☐	☐	☐	☐	☐
Max und ich arbeiten auf ein gemeinsames Ziel hin.	☐	☐	☐	☐	☐	☐	☐
Max und ich haben festgelegt, was für mich wichtig ist.	☐	☐	☐	☐	☐	☐	☐
Die Art und Weise, wie Max und ich zusammen arbeiten, ist richtig.	☐	☐	☐	☐	☐	☐	☐

Teil C: Paper Assessment

Sven hat eine Beschreibung des Squats mit Illustrationen auf dieses Papier gezeichnet, als Erinnerung für Sie. Sie sind nun zuhause und müssen die Übungen machen.

C1. Wie anstrengend war es die Übung auszuführen?

- 6 Gar keine Anstrengung ☐
- 7 ☐
- 8 ☐
- 9 Sehr leicht ☐
- 10 ☐
- 11 Leicht ☐
- 12 ☐
- 13 Etwas schwer ☐
- 14 ☐
- 15 Schwer ☐
- 16 ☐
- 17 Sehr schwer ☐
- 18 ☐
- 19 Extrem schwer ☐
- 20 Maximale Anstrengung ☐

C2. Bitte beurteilen Sie folgende Aussagen von stimme ganz und gar nicht zu (1) bis stimme vollkommen zu (7).

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Die Papierinstruktion hat mir Spass gemacht.	☐	☐	☐	☐	☐	☐	☐

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Ich konnte der Papierinstruktion sehr gut folgen	☐	☐	☐	☐	☐	☐	☐
Ich fand die Papierinstruktion nützlich um an die Übungen erinnert zu werden	☐	☐	☐	☐	☐	☐	☐
Die Papierinstruktion hat mich motiviert, die Übungen durchzuführen	☐	☐	☐	☐	☐	☐	☐
Die Papierinstruktion hat mir geholfen, die Übungen richtig durchzuführen	☐	☐	☐	☐	☐	☐	☐

C3.

	Ganz und gar nicht mehr (- - -)	Nicht mehr (- -)	Eher nicht mehr (-)	Weder noch (0)	Schon etwas (+)	Sehr (++)	In jedem Fall (+++)
Wie sehr würden Sie gerne diese Papierinstruktion weiter nutzen?	☐	☐	☐	☐	☐	☐	☐

C4.

	Sehr schwierig(- - -)	Ziemlich schwierig (- -)	Eher schwierig (-)	Neutral (0)	Eher einfach (+)	Ziemlich einfach (++)	Sehr einfach (+++)
Wie einfach/schwierig war es die Übung auszuführen?	☐	☐	☐	☐	☐	☐	☐

C5.

	Absolut falsch(- - -)	Ziemlich falsch (- -)	Eher falsch (-)	Neutral (0)	Eher korrekt (+)	Ziemlich korrekt (++)	Absolut korrekt (+++)
Wie korrekt/falsch haben Sie, ihrer Meinung nach die Übung gemacht?	☐	☐	☐	☐	☐	☐	☐

C6.

	Gar nicht informativ(- - -)	Nicht informativ (- -)	Eher nicht informativ (-)	Neutral (0)	Eher informativ (+)	Ziemlich informativ(+ +)	Sehr informativ (+++)
Wie informativ war die Papierinstruktion beim Erklären der Übung?	☐	☐	☐	☐	☐	☐	☐

C7.

	Gar nicht vertrauenswürdig(- - -)	Nicht verstrauenswürdig (- -)	Eher nicht verstrauenswürdig (-)	Neutral (0)	Eher verstrauenswürdig (+)	Ziemlich vertrauenswürdig(++)	Sehr verstrauenswürdig (+++)
Wie vertrauenswürdig fanden Sie die Instruktionen der Papierinstruktion?	☐	☐	☐	☐	☐	☐	☐

C8.

	Sehr unkomfortabel(- - -)	Ziemlich unkomfortabel (- -)	Eher unkomfortabel (-)	Neutral (0)	Eher komfortabel (+)	Ziemlich komfortabel(++)	Sehr komfortabel (+++)
Wie komfortabel/unkomfortabel war es die Übung mit Papierinstruktion zu machen?	☐	☐	☐	☐	☐	☐	☐

C9.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie viel geistige Anstrengung war bei der Informationsaufnahme und -verarbeitung erforderlich?	☐	☐	☐	☐	☐	☐	☐

C10.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie hoch war ihre Frustration während der Ausführung mit der Papierinstruktion? (unsicher, entmutigt, gestresst versus sicher, zufrieden, entspannt)	☐	☐	☐	☐	☐	☐	☐

Teil D: Video Assessment

Sven sendet Ihnen auf ihr Smartphone dieses Video über wie man den Squat machen soll. Nun sind Sie zuhause und sollen die Übungen machen.

D1. Wie anstrengend war es die Übung auszuführen?

6 Gar keine Anstrengung ☐
7 ☐
8 ☐
9 Sehr leicht ☐
10 ☐
11 Leicht ☐
12 ☐
13 Etwas schwer ☐
14 ☐
15 Schwer ☐
16 ☐
17 Sehr schwer ☐
18 ☐
19 Extrem schwer ☐
20 Maximale Anstrengung ☐

D2. Bitte beurteilen Sie folgende Aussagen von stimme ganz und gar nicht zu (1) bis stimme vollkommen zu (7).

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Die Videoinstruktion hat mir Spass gemacht	☐	☐	☐	☐	☐	☐	☐
Ich konnte der Videoinstruktion sehr gut folgen	☐	☐	☐	☐	☐	☐	☐
Ich fand die Videoinstruktion nützlich um an die Übungen erinnert zu werden	☐	☐	☐	☐	☐	☐	☐

	stimme ganz und gar nicht zu (- - -)	stimme nicht zu (- -)	stimme eher nicht zu (-)	weder noch (0)	stimme eher zu (+)	stimme zu (++)	stimme vollkommen zu (+++)
Die Videoinstruktion hat mich motiviert, die Übungen durchzuführen	☐	☐	☐	☐	☐	☐	☐
Die Videoinstruktion hat mir geholfen, die Übungen richtig durchzuführen	☐	☐	☐	☐	☐	☐	☐

D3.

	Ganz und gar nicht mehr (- - -)	Nicht mehr (- -)	Eher nicht mehr (-)	Weder noch (0)	Schon etwas (+)	Sehr (++)	In jedem Fall (+++)
Wie sehr würden Sie gerne diese Videoinstruktion weiter nutzen?	☐	☐	☐	☐	☐	☐	☐

D4.

	Sehr schwierig(- - -)	Ziemlich schwierig (- -)	Eher schwierig (-)	Neutral (0)	Eher einfach (+)	Ziemlich einfach (++)	Sehr einfach (+++)
Wie einfach/schwierig war es die Übung auszuführen?	☐	☐	☐	☐	☐	☐	☐

D5.

	Absolut falsch(- - -)	Ziemlich falsch (- -)	Eher falsch (-)	Neutral (0)	Eher korrekt (+)	Ziemlich korrekt (++)	Absolut korrekt (+++)
Wie korrekt/falsch haben Sie, ihrer Meinung nach die Übung gemacht?	☐	☐	☐	☐	☐	☐	☐

D6.

	Gar nicht informativ(- - -)	Nicht informativ (- -)	Eher nicht informativ (-)	Neutral (0)	Eher informativ (+)	Ziemlich informativ(++)	Sehr informativ (+++)
Wie informativ war die Videoinstruktion beim Erklären der Übung?	☐	☐	☐	☐	☐	☐	☐

D7.

	Gar nicht vertrauenswürdig(- - -)	Nicht verstrauenswürdig (- -)	Eher nicht verstrauenswürdig (-)	Neutral (0)	Eher verstrauenswürdig (+)	Ziemlich vertrauenswürdig(++)	Sehr verstrauenswürdig (+++)
Wie vertrauenswürdig fanden Sie die Instruktionen der Videoinstruktion?	☐	☐	☐	☐	☐	☐	☐

D8.

	Sehr unkomfortabel(- - -)	Ziemlich unkomfortabel (- -)	Eher unkomfortabel (-)	Neutral (0)	Eher komfortabel (+)	Ziemlich komfortabel(++)	Sehr komfortabel (+++)
Wie komfortabel/unkomfortabel war es die Übung mit Videoinstruktion zu machen?	☐	☐	☐	☐	☐	☐	☐

D9.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie viel geistige Anstrengung war bei der Informationsaufnahme und -verarbeitung erforderlich?	☐	☐	☐	☐	☐	☐	☐

D10.

	Sehr gering(- - -)	Ziemlich gering (- -)	Eher gering (-)	Neutral (0)	Eher hoch (+)	Ziemlich hoch(++)	Sehr hoch(+++)
Wie hoch war ihre Frustration während der Ausführung mit der Videoinstruktion? (unsicher, entmutigt, gestresst versus sicher, zufrieden, entspannt)	☐	☐	☐	☐	☐	☐	☐

Teil E: Post-test Questions

E1. **Welche Art des Coachings hat Ihnen am besten gefallen? Vergeben Sie jeweils einen 1. Platz (hat am meisten gefallen), einen 2. Platz und einen 3. Platz (hat am wenigsten gefallen).**

	Papier Broschüre	Video-basiertes Coaching	Virtueller Physiotherapeut
1. Rang	☐	☐	☐
2. Rang	☐	☐	☐
3. Rang	☐	☐	☐

E2. **Weshalb haben Sie diese Rangfolge gewählt?**

Herzlichen Dank. Die Daten wurden gespeichert.

Neue Umfrage starten

Appendix G

Questionnaire Results Raw Data (German)

This appendix provides the raw data of the questionnaire results. Table G.1 includes information on the question codes and in Table G.2, G.3 and G.4 the raw response data (in German) is presented.

EARS1	"Ich mache meine Übungen so oft wie empfohlen."
EARS2	"Ich ändere meine Übungen ab, so dass sie mir passen."
EARS3	"Ich komme nicht dazu, meine Übungen zu machen."
EARS4	"Andere Verpflichtungen halten mich davon ab, die Übungen zu machen."
EARS5	"Ich fühle mich sicher, meine Übungen richtig zu machen."
EARS6	"Ich habe keine Zeit meine Übungen zu machen."
EARS7	"Ich bin mir nicht sicher wie ich meine Übungen machen muss."
EARS8	"Ich mache manche, aber nicht alle meiner Übungen."
EARS9	"Ich mache meine Übungen nicht, wenn ich müde bin."
EARS10	"Ich mache weniger Übungen als von meinem Therapeuten empfohlen."
EARS11	"Ich baue meine Übungen in meine reguläre Routine ein."
EARS12	"Ich mache meine Übungen, weil sie mir Spass machen."
EARS13	"Meine Familie und Freunde ermutigen mich meine Übungen zu machen."
EARS14	"Ich höre auf meine Übungen zu machen, wenn mein Schmerz schlimmer wird."
EARS15	"Ich vergesse es, meine Übungen zu machen."
EARS16	"Ich mache meine Übungen um meine gesundheitlichen Probleme zu reduzieren."
EARS17	"Wenn meine Schmerzen besser werden mache ich weiterhin meine Übungen."
Scale	1 "Stimme ganz und gar nicht zu" - 7 "Stimme vollkommen zu"
borgScale	"Wie anstrengend war es die Übung auszuführen?"
Scale	6 "Gar keine Anstrengung" - 20 "Maximale Anstrengung"
[PEN]	"Die [Art des Coachings / Videoinstruktion / Papierinstruktion] hat mir Spass gemacht."
[PEU]	"Ich konnte [dem Coaching / der Videoinstruktion / der Papierinstruktion] sehr gut folgen."
[PU1]	"Ich fand die [Art des Coachings / Videoinstruktion / Papierinstruktion] nützlich um an die Übungen erinnert zu werden."
[PU2]	"Die [Art des Coachings / Videoinstruktion / Papierinstruktion] hat mich motiviert, die Übungen durchzuführen."
[PU3]	"Die [Art des Coachings / Videoinstruktion / Papierinstruktion] hat mir geholfen, die Übungen richtig durchzuführen."
Scale	1 "Stimme ganz und gar nicht zu" - 7 "Stimme vollkommen zu"
[INT]	"Wie sehr würden Sie gerne diese [Art des Coachings / Videoinstruktion / Papierinstruktion] weiter nutzen?"
Scale	1 "Ganz und gar nicht mehr" - 7 "In jedem Fall"
[DIF]	"Wie einfach/schwierig war es die Übung auszuführen?"
Scale	1 "Sehr schwierig" - 7 "Sehr einfach"
[COR]	"Wie korrekt/falsch haben Sie, ihrer Meinung nach die Übung gemacht?"
Scale	1 "Absolut falsch" - 7 "Absolut korrekt"
[INF]	"Wie informativ war [das Coaching / die Videoinstruktion / die Papierinstruktion] beim Erklären der Übung?"
Scale	1 "Gar nicht informativ" - 7 "Sehr informativ"
[TRU]	"Wie vertrauenswürdig fanden Sie die Instruktionen [des Coachings / der Videoinstruktion / der Papierinstruktion]?"
Scale	1 "Gar nicht vertrauenswürdig" - 7 "Sehr vertrauenswürdig"
[COM]	"Wie komfortabel/unkomfortabel war es die Übung mit [dem Coaching / der Videoinstruktion / der Papierinstruktion] zu machen?"
Scale	1 "Sehr unkomfortabel" - 7 "Sehr komfortabel"
[NAS1]	"Wie viel geistige Anstrengung war bei der Informationsaufnahme und -verarbeitung erforderlich?"
[NAS1]	"Wie hoch war ihre Frustration (unsicher, entmutigt) während der Ausführung mit [dem Coaching / der Videoinstruktion / der Papierinstruktion]?"
Scale	1 "Sehr gering" - 7 "Sehr hoch"
Coach [SAI1]	"Max und ich respektieren einander."
Coach [SAI2]	"Ich habe das Gefühl, dass Max mich schätzt."
Coach [SAI3]	"Ich glaube, dass Max zu mir steht, auch wenn ich etwas mache, was Max nicht gut findet."
Coach [SAI4]	"Max und ich arbeiten auf ein gemeinsames Ziel hin."
Coach [SAI5]	"Max und ich haben festgelegt, was für mich wichtig ist."
Coach [SAI6]	"Die Art und Weise, wie Max und ich zusammen arbeiten, ist richtig."
Scale	1 "Stimme ganz und gar nicht zu" - 7 "Stimme vollkommen zu"

Table G.1: Question code information, question formulations and scales in german

Question	P1	P2	P3	P4	P5	P6	P7	P8	P10	P11	P12	P9	P13	P14	P15
method1	Vid	Vid	Pap	Vid	Pap	Coa	Coa	Pap	Vid	Pap	Pap	Coa	Vid	Coa	Coa
method2	Pap	Coa	Coa	Coa	Vid	Vid	Pap	Coa	Coa	Vid	Vid	Pap	Pap	Vid	Pap
method3	Coa	Pap	Vid	Pap	Coa	Pap	Vid	Vid	Pap	Coa	Coa	Vid	Coa	Pap	Vid
EARS1	6	5	5	6	5	1	6	6	7	6	7	6	6	7	7
EARS2	2	1	2	1	3	1	2	5	1	2	2	1	2	6	1
EARS3	2	3	2	2	4	6	3	2	1	2	2	2	1	2	7
EARS4	2	5	2	3	5	6	5	2	2	2	1	2	1	2	6
EARS5	5	6	6	5	4	7	6	6	6	5	6	6	6	6	6
EARS6	1	3	2	1	3	5	5	2	1	4	2	2	1	2	1
EARS7	2	1	2	3	3	1	3	6	1	3	2	2	1	2	6
EARS8	2	1	2	2	5	4	3	5	1	2	1	2	2	3	1
EARS9	6	1	3	4	6	6	6	3	2	2	1	2	2	3	5
EARS10	2	3	3	2	6	4	2	2	2	2	3	2	1	2	1
EARS11	7	5	6	5	5	7	7	6	6	6	4	5	7	6	7
EARS12	4	3	5	4	3	4	6	4	5	2	4	5	6	2	6
EARS13	2	1	3	4	4	4	5	4	6	1	4	7	5	4	4
EARS14	6	3	3	5	5	2	7	6	1	5	6	7	2	6	6
EARS15	2	4	3	1	6	5	1	2	2	2	2	4	2	2	1
EARS16	6	7	7	7	7	6	7	6	7	6	7	7	7	7	7
EARS17	6	5	5	5	3	2	6	6	6	3	5	7	7	6	7
borgScaleCoach	7	12	12	11	12	9	8	11	6	7	7	12	8	11	7
Coach [PEN]	6	7	6	1	5	6	7	5	1	5	7	5	5	7	6
Coach [PEU]	7	7	5	7	4	7	7	7	6	5	7	6	7	6	5
Coach [PU1]	6	6	6	2	6	7	7	5	1	7	6	7	7	5	5
Coach [PU2]	7	7	6	1	5	6	7	5	1	6	7	5	7	6	5
Coach [PU3]	7	7	6	5	5	6	7	6	5	6	6	4	6	5	7
Coach [INT]	6	7	6	1	5	5	7	5	1	6	7	4	5	6	4
Coach [DIF]	7	5	5	6	3	6	5	7	6	6	7	4	7	5	6
Coach [COR]	6	6	5	5	5	6	6	5	6	5	4	5	6	6	6
Coach [INF]	7	7	6	5	7	6	6	7	6	6	7	4	7	6	7
Coach [TRU]	6	7	6	2	6	6	7	6	3	6	6	4	7	6	7
Coach [COM]	6	6	5	1	3	4	7	5	3	3	5	6	4	5	3
Coach [NAS1]	1	4	4	2	4	3	3	2	1	3	3	4	1	2	3
Coach [NAS1]	1	3	3	4	5	2	1	2	4	2	2	4	1	1	5
Coach [SAI1]	4	7	6	2	6	6	6	7	1	5	7	7	7	5	6
Coach [SAI2]	4	4	6	3	6	5	7	5	5	5	7	7	7	5	6
Coach [SAI3]	4	5	6	6	6	7	6	7	4	5	7	7	7	5	4
Coach [SAI4]	4	6	6	4	6	7	7	5	4	6	7	7	7	6	7
Coach [SAI5]	4	1	1	3	5	5	6	6	1	5	6	1	7	4	4
Coach [SAI6]	6	6	4	3	4	6	7	6	2	6	6	4	7	5	4
borgScalePaper	7	12	11	11	13	10	9	11	6	7	6	12	9	14	7
Paper [PEN]	4	2	4	2	4	4	5	4	5	4	4	5	5	4	6
Paper [PEU]	3	6	4	6	3	6	7	5	6	6	7	6	7	4	7
Paper [PU1]	4	4	5	5	5	3	6	6	7	3	7	7	7	3	4
Paper [PU2]	5	4	4	1	5	2	3	5	5	3	5	6	4	4	4
Paper [PU3]	5	6	3	5	4	4	5	6	6	6	5	6	7	4	6
Paper [INT]	3	5	5	5	5	5	5	5	6	5	5	7	6	5	5
Paper [DIF]	6	5	5	5	4	6	5	5	6	5	4	4	7	4	6
Paper [COR]	6	6	4	3	5	6	6	5	6	5	4	5	6	5	5
Paper [INF]	4	6	5	3	4	5	6	6	6	5	6	6	6	4	6
Paper [TRU]	6	6	4	5	5	6	7	6	6	4	5	7	7	4	6
Paper [COM]	6	3	5	5	3	3	5	5	7	3	6	6	6	4	6
Paper [NAS1]	5	5	4	2	5	5	5	6	1	3	5	4	3	4	3
Paper [NAS2]	1	3	3	4	5	4	4	1	1	3	6	1	1	1	4

Table G.2: Questionnaire results raw data (German) part 1

Question	P1	P2	P3	P4	P5	P6	P7	P8	P10	P11	P12	P9	P13	P14	P15
borgScaleVideo	7	11	12	11	12	11	9	11	8	7	6	12	9	13	8
Video [PEN]	6	4	5	7	6	4	5	5	6	5	7	5	3	5	6
Video [PEU]	7	6	5	7	6	3	6	6	6	5	7	6	5	5	7
Video [PU1]	2	4	5	7	6	2	6	5	6	2	6	6	5	4	4
Video [PU2]	4	4	6	6	6	2	3	5	6	3	6	6	4	5	6
Video [PU3]	6	6	5	7	6	2	7	6	7	6	7	6	5	5	6
Video [INT]	6	5	5	6	6	3	5	5	6	5	7	6	2	5	6
Video [DIF]	6	5	5	6	4	6	6	6	6	5	6	4	6	4	6
Video [COR]	6	5	5	5	5	6	6	6	6	5	5	5	5	5	6
Video [INF]	6	7	5	6	5	4	5	6	7	5	6	5	5	5	6
Video [TRU]	6	6	6	6	6	4	7	6	6	6	6	6	7	4	6
Video [COM]	6	6	6	7	6	4	6	6	7	6	5	5	4	6	6
Video [NAS1]	1	2	2	4	2	6	5	3	1	3	4	4	2	4	3
Video [NAS2]	1	3	2	3	2	5	4	2	2	3	4	1	1	2	4

Table G.3: Questionnaire results raw data (German) part 2

P	Rang (1., 2., 3.)	Weshalb haben Sie diese Rangfolge gewählt?
1	3,2,1	-
2	3,2,1	virtueller Physio ist etwas neues, noch nie so gesehen. Motiviert dieses zu nutzen. Zudem war ich erstaunt, hat er mich bei der Übung korrigiert. 2. Rang für das Video, weil man die Übung in Motion sieht, was klar dem Papier überlegen ist, aber dem videobasierten Coaching unterlegen, weil keine Korrekturfunktino enthalten ist.
3	3,2,1	Virtueller Therapeut bietet ständiges Anschauungsbeispiel, Korrekturen erfolgen ist interaktiv, Video gibt zumindest ein Anschauungsbeispiel- das fehlt beim Papier"
4	2,1,3	-
5	2,3,1	Video-basiertes Coaching ist eine gute Mischung zwischen Broschüre (nur auf Papier, ich kann es nirgends abschauen und nachmachen) und dem virtuellen Physio (etwas aufwändiger, nicht so bequem mit der Brille und schwierig Max ganz zu sehen ohne mit dem Kopf eine unbequeme Haltung einzunehmen).
6	3,1,2	Abgesehen von der etwas unbequemen Brille und dem eingeschränkten Gesichtsfeld war der virtuelle Physio motivierend und gab direkte Rückmeldung. Im Video fiel es mir schwer, die Anweisungen beim Ausführen der Übung im Kopf zu behalten.
7	3,2,1	Der Virtuelle coach ist sehr motivierend und die Übungen machten spass- da sie für mich spielerisch wirkten. Ich vergass das "müssen"
8	2,3,1	Die Papier Broschüre ist etwas statisches und es ist eine gute Erinnerungsstütze, aber nicht wirklich praktisch für einen dynamischen Ablauf. Der virtuelle Physiotherapeut macht Spass, benötigt vom Gefühl her aber viel mehr Zeit. Ausserdem fand ich etwas unpraktisch, dass es mit der Brille tendenziell schwierig war, die eigene Bewegung zu sehen (ich sehe den virtuellen Coach, der es korrekt macht, kann aber meine eigenen Beine schlecht sehen, um meine Knie zu kontrollieren).
9	3,1,2	-
10	2,1,3	Im Video sieht man 1:1 wie die Übung gemacht werden sollte daher Platz 1. Papierbroschüre braucht schon mehr Vorstellungskraft ist aber umsetzbar da der Physiotherapeut die Übung schonmal vorgezeigt hat. Video Coaching ist für mich keine Option. man kommt sich komisch vor mit der Brille- finde das interagieren mit Max als kindisch. Leider sieht man bei der Ausführung der Übungen nur den Kopf von Max. Um ihn ganz zu sehen muss man den Kopf ständig bewegen was von der eigentlichen Übung ablenkt."
11	3,2,1	Max war eine Methode die ich noch nie so gesehen habe. Er motivierte mich- die Übungen zu machen. Ich würde wohl vor allem die Erinnerungsfunktion auf dem Handy schätzen.
12	2,3,1	etwas Neues ist immer spannend und motiviert. Jedoch ist der virtuelle Physiotherapeut nicht ganz einfach "zu tragen". Je nach Übung wahrscheinlich nicht die beste Eignung. Mit dem Video habe ich wahrscheinlich mehr Flexibilität
13	1,3,2	Papier ist für mich fast so verständlich/einfach wie Max. Ich befürchte- dass ich durch Max mehr Zeit brauche und deshalb weniger flexible wäre. Videocoaching war für mich visuell nicht attraktiv genug und nicht informativ genug.
14	3,2,1	Der virtuelle Therapeut erweitert die Uebungen (gamification) was besonders Spass gemacht hat. Video ist immer noch hilfreicher als papierhinweise. in der Praxis erhält man oft nicht mal einen Hinweis auf Papier sondern nur mündliche Erklärungen.
15	2,3,1	Die gesamte Apparatur vom PhysioCoach ist zu schwer und zu unbequem.

Table G.4: Reasons for rank choice, last question (German)

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