Personalized Virtual Coaching for Lifestyle Support: Principles for Design and Evaluation

Olga Kulyk*, Rieks op den Akker†, Randy Klaassen†, Lisette van Gemert-Pijnen*
*Center for eHealth Research and Disease Management, University of Twente, Enschede, The Netherlands
†Human Media Interaction, University of Twente, Enschede, The Netherlands
{o.a.kulyk, h.j.a.opdenakker, r.klaassen, l.vangemert-pijnen}@utwente.nl

***Abstract*—There is a fast growing number of behavior change support systems (BCSS) aiming at supporting a healthy lifestyle. Existing lifestyle coaching services offer individual users access to web portals where they can communicate about a growing number of ingredients of everyday life concern: physical activity, nutrition, medication, mood, sleep and sexual health. Mobile technology in combination with body worn sensors support user's awareness of their physical condition and lifestyle. Despite the large number of available lifestyle interventions and pilot trials, only very few are successfully transferred into the real health care practice. Low usability and lack of transparency on the reliability and trustworthiness of the information are just a few examples of the major barriers for successful implementation.Traditional metric for measuring effects of behavior change support system are not suited for early stage health technologies. Professionals from the field of health and social psychology, and potential end users should be involved not only in the design and effects evaluation of BCSS, but also in the iterative process evaluation of these systems. Qualitative evaluation studies focused on the user experiences with technology can help researchers to understand what persuasive features can enhance adherence, motivate people and how this technology should be further developed to optimally match the needs of real users in daily healthcare practice. Based on two user studies, we present general guidelines for design and evaluation of lifestyle support systems with personalized virtual coaching. The first field study focuses on design and evaluation of a mobile physical activity coaching system. The second user study focuses on design factors that influence the attitudes of high-risk adolescents towards virtual coaching in mobile eHealth applications and social media. We present a new approach that integrates an animated digital coach in an activity monitoring lifestyle change support system. The main contribution of this paper are practical recommendations for persuasive design and evaluation methodology combining established methods from Human Computer Interaction and eHealth.**

Keywords-Mobile Activity Monitoring, Personalized eHealth; Persuasive Feedback, Usability; Virtual Coaching; Behavior Change; Lifestyle Support; Human Computer Interaction

I. INTRODUCTION

Recent massive media attention to the obesity epidemic worldwide and a growing number of patients with chronic diseases raise the demand for encouraging physical activity and for raising health awareness [1][2]. Next to classical web-based interventions, eHealth behavior change support systems for healthy lifestyle promotion aim to motivate patients to healthy behavior change [3][4][5]. Some systems become proactive and provide real time information and feedback to their users based on data gathered through various sensors and personal devices [6][7].

Despite the large number of existing lifestyle interventions and pilot trials, only very few are successfully transferred into the real healthcare practice [8][9]. Users often have problems to navigate through the system, they get lost or they do not find the information they are looking for [10]. Low usability and lack of transparency on the reliabilty and trustworthiness of the information are some of the major barriers for successful implementation [5][8][9]. There is also a lack of standardization for interoperability between various parts of the systems and a lack of connection between the feedback, the actual usage patterns and the task a user is involved in [11]. These problems are often caused by a design that does not meet the actual needs of the target users while using the system and a lack of connection with offline, daily, activities. A holistic design approach for eHealth intervention development, which we use in our research has proven to contribute in overcoming these barriers [9].

This paper presents new insights and general guidelines for design and evaluation of lifestyle change support systems that uses personalized virtual coaching [1]. The two user studies discussed in this paper represent different perspectives on lifestyle support systems, combining methods from Human Computer Interaction and eHealth. The first field study focuses on design and evaluation of mobile physical activity coaching for diabetes patients and office workers. This study takes a Human Computer Interaction (HCI) perspective and focuses on the effects of using a virtual animated character at the user interface. It was performed at the Human Media Interaction group of the Computer Science Department at the University of Twente in the context of the EU Artemis project Smarcos.

The second user study focuses on design factors that influence the attitudes of adolescents towards virtual coaching in mobile eHealth applications and social media. This study was performed at the Center for eHealth Research and Disease Management, Psychology Health and Technology group of the Behavioral Sciences Department at the same university. The data analysis for both studies is integrated using the persuasive system design model [12]. We present persuasive factors and general design guidelines for personalized virtual coaching in mobile health applications.

In the next section, we first highlight findings from related work on physical activity monitoring, virtual coaching, mobile eHealth applications and serious gaming for lifestyle support. After that, we present a new approach for a multi-device coaching system and general design guidelines based on the outcomes of two user studies on virtual coaching for lifestyle support. The first study describes results of the user evaluation of the mobile physical activity coaching system for office workers and diabetes patients. The second study focuses on persuasive factors and attitudes of high-risk adolescents towards virtual coaching, social media and mobile apps for sexual health promotion. Summarizing the main outcomes, we then present recommendations for the design and evaluation of lifestyle support systems with personalized virtual coaching. Finally, we present the main conclusions and discuss future work.

II. State of the Art

There have been various attempts in categorizing eHealth technology [6][9][13][14][15]. In this paper, we focus on monitoring physical activity and health related parameters (blood pressure, weight) in lifestyle interventions for preventive professional care support. A categorization is based on the type of platform that the eHealth technology is realized on: stand alone devices; integrated web-based interventions and personal mobile devices; or a combination of various devices to monitor online and offline activities of a target user.

A. Physical Activity Monitoring and Coaching

Wearable health technology, such as activity sensors, is often used as a surveillance tool to objectively assess physical activity patterns [7][16][17]. They provide an inexpensive measure of physical activity by counting the number of steps taken per day, enabling the accumulative measurement of occupational, leisure time, and household activity, along with activity required for everyday transportation. Real time monitoring offers the user immediate feedback on the accumulated step count which is important for motivating him to sustain or improve his activity level[17]. For a thorough review on this topic see [18].

Engaging patients requires user friendly interfaces and user friendly interaction with the systems. Patients often have to cope with various physiological measurements instruments (either active or passive): blood pressure, blood sugar and weight. Willingness to measure these parameters strongly depends on the complexity of the user interface of the measuring device or sensor, as well as the data transfer process [19].

Based on an extensive literature study, H. op den Akker et al. [20] identified six key areas for research to improve digital coaching for physical activity by tailoring to the individual user. Two of them are of interest here: advanced Human-Computer Interaction (HCI) and pervasive coaching. To increase perceived intelligence of a coaching system, a virtual coach offers an interesting opportunity as an interface metaphor. Bickmore et al. [3] studied the effects of interventions for multiple health behaviors using conversational agents as a coaching system. This study showed that virtual conversational agent as a coach can have a positive effect on perceived relationship of a patient with an eHealth system.

Computer tailoring and personalized eHealth offer great potential for motivating people by providing personal information and feedback [21]. Characteristics of an intervention, such as enabling personal goal setting and providing tailored feedback are thought to be among the important factors related to the use of lifestyle change support systems. Next to tailoring, personal feedback needs to be dynamic to provide new information and real time feedback on the daily activities. The user study of Consolvo et al. [16] reports that negative feedback or paternalism has a negative impact on the users.

B. Mobile eHealth and Coaching

Mobile devices providing personalized feedback to influence physical activity behavior are gaining more and more popularity [22]. There are few examples of mobile health applications (apps) specific for behavior change and physical activity support [6][22][23]. Despite a huge range of health-related apps on the market, there is little in depth research on user experiences and views on a wide range of features that apps can provide.

Fanning et al. [22] present extensive review on efficacy of mobile devices in the physical activity and recommendations for implementation. This study concludes that mobile technology applied in behavior change interventions is an effective tool for increasing physical activity. User studies in mobile health research are rarely performed with young adults, though adolescents are forerunners of mobile technology. Dennison et al. [23] present the findings of a focus group study with students on the use of mobile apps to support a healthy lifestyle, the attitude of adolescents on the usefulness of various features of such apps. The results suggest that the most important factors influencing the use and uptake of mobile apps are accuracy, legitimacy, security, effort required, and immediate effects on mood. Another features that young adults valued were ability to record and track own behavior and goals, as well as the ability to receive advice and real time information. Interesting finding from this study is that context-sensing capabilities of mobile apps and social media features were perceived as unnecessary.

Consolvo et al. [16] reports a long-term user evaluation with the UbiFit system, which aims at raising individual awareness on physical activity level. The results show that glanceable representations of information on personal, mobile displays can stimulate the person to do more exercises. These findings are consistent with another study [24].

C. Serious Gaming for Lifestyle Support

New forms of entertainment media such as serious gaming are used for promoting healthy lifestyle [25]. The general purpose of serious games can be defined as: *'games to train, educate, and persuade'* [26](pp. 14). The latest research shows that the use of game mechanics for supporting non-leisure activities has grown beyond serious games. This trend has being defined by the term gamification: *'the use of game design elements in non-game contexts'* [27](pp. 2). Serious gaming and interactive gaming elements embedded in eHealth technology offer great potential in innovative opportunities for engaging adolescents and other patients in interventions promoting healthy nutrition habits and physical activity changes

that can contribute to obesity prevention and healthier lifestyle [25].

Existing applications that incorporate some gaming elements and personal visual feedback demonstrate the lack of a multidisciplinary approach in designing technology applications for care [28]. The main drawback of the current gamification applications aiming at behaviour change is the lack of actual benefits for the end user and the lack of focus on positive user experience. In general, there is a lack of research and evidence on the long-term user evaluations and implementation of such health-oriented gaming technologies [29].

D. Evaluation of Lifestyle Support Systems

The goal of every (health) behavior change support system is to change a certain behavior or a habit. User evaluations of a behavior change support system are usual focused to show that the intended change in behavior did actually took place. Measuring change in behavior requires multi-year studies with repeated follow-ups [30]. Changes in behavior on short-term are hard to measure and if they occur these changes are often short-lived. According to Klasnja [30] evaluating behavior change in the traditional clinical sense is not the right metric for early stage technology that are developed in the context of human computer interaction. Evaluating behavior change support systems in the context of the field of human computer interaction can focus on narrower notion of efficacy by looking at the outcomes of particular interventions strategies and whether the system is doing what it intended to do, even in a early stage of the development of the system. Qualitative studies focused on the experiences with technology can help researchers understand who and why a system is working and how the system should be further developed.

Technologies that promote a healthier lifestyle are gaining popularity in the human computer interaction discipline. Paradoxically, the evaluation of such technologies remains rather unclear [31]. Different frameworks, like the Framework for Ubiquitous Computing Evaluation Areas (UEAs) by Scholz and Consolvo [32], the persuasive system design model (PSD) by Oinas-Kukkonen and Harjumaa [12] and the Fogg Behavior Model (FBM) [33] could be used to evaluate behavior change systems and the features and functionalities of these systems. Evaluating the the perceived persuasiveness of a behavior change support system is an ongoing challenge [31]. Klasnja et al. [30] propose multi-methods approaches for evaluating behavior change support systems where combining qualitative and quantitative methodologies should be combined to provide deeper insights into users experiences with technologies.

III. User evaluations of a mobile animated activity coaching system

As humans interact with many different devices during the day, cross media systems offer the opportunity for the activity coach to travel with the user across those devices. Depending on the needs and context of the user, coaching can thus be provided on the most suitable device (e.g., smartphone, PC, smart television) [34].

A. Digitial Coaching Architectures

A multi-device digital coaching can have a more *centralized* or a more *decentralized* architecture. The main difference is in the measure of autonomy of the mobile coaching application. The Continuous Care & Coaching Platform (C3PO), developed at Roessingh Research and Development (RRD) in the Netherlands, enables continuous remote monitoring of elderly patients and patients with chronic disorders [35]. In the C3PO platform, there is only one device with which the patients users interact, the smartphone. The care givers can view patient data that is uploaded to a server. An activity monitoring and feedback system was designed to guide patients in reaching a healthy daily activity pattern. Objective daily activity is assessed using an inertial sensor node that captures and communicates wireless. The sensor can store large amount of data and send the data over Bluetooth to a PDA (an Android based HTC Desire) where further processing and communication to the patient is handled. The users receive feedback on their smartphone at scheduled times or if their activity level calls for this. In this *decentralized* architecture the coaching rules reside on the client-side mobile. In contrast to this, in the *centralized* architecture of the Smarcos platform the coaching rules reside on the server (see Fig. 1 for an overview). Based on server side stored sensor data or on fixed times, the server sends a message to the client, who can receive the message on the device of his own choice. To upload activity data the user has to connect his sensor to the internet.

In the Smarcos system, feedback is a reminder to connect the activity monitor to upload data, a motivating message when activity is less than the target or an overview of daily, weekly and monthly scores. A drawback of the Smarcos system compared to the RRD system is that feedback is not real-time. The RRD system allows immediate feedback based on recent data collected from the sensor. A call for urgent medication intake (e.g., in a diabetes I medication coach) requires real-time feedback. In the Smarcos system, scores are presented as percentages of a user set target score and in terms of kCal. The user can get these activity overviews on his mobile device app, as well as via a web portal.

B. User Evaluations: Animated Virtual Coach

User evaluations were performed throughout the development of the Smarcos coaching system [34] for physical activity support and diabetes II patients. We performed short user evaluation with diabetes patients and office workers. We focused on the graphical user interface, on the interaction and on personal feedback in particular. We looked at timing, content, modality and presentation format. We are particularly interested in the application of animated virtual humans and multi-modal natural dialog as a means for interaction between the user and the digital coach. At the Human Media Interaction group we developed mobile technology for responsive animated Embodied Conversational Agents (ECAs) [37] for the presentation of feedback on a mobile app. The system can produce ECA behaviors (eye blink, eye gaze, head movements, lip sync with natural speech and facial expressions) specified in the Behavior Markup Language (BML) [38]. In the centralized Smarcos system the server sends a feedback message to a client containing a BML specification. The BML contains the

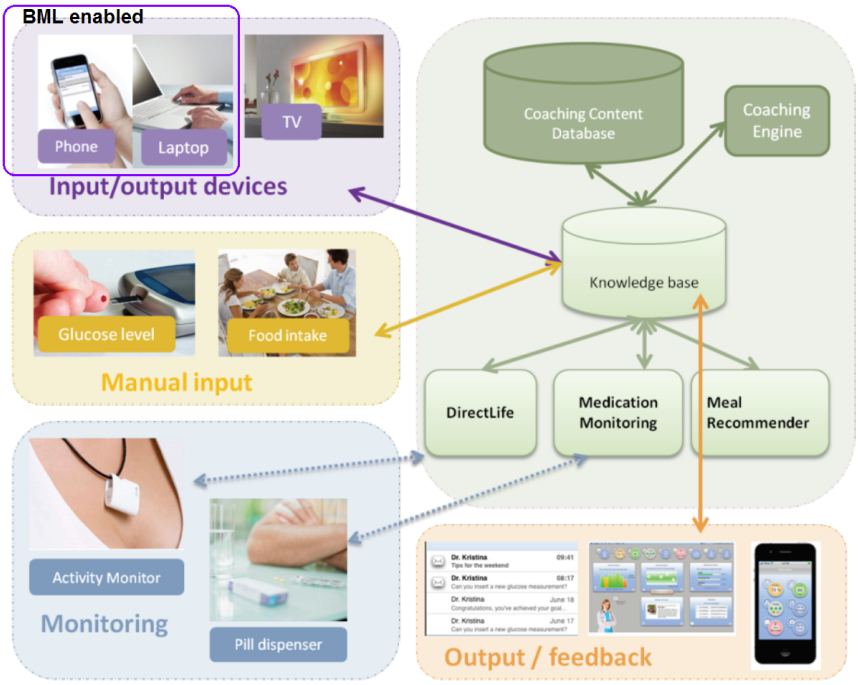

Figure 1: Overview of the multi-sensor multi-device digital coaching system developed in the Smarcos project [36].

text to be pronounced by the ECA as well as the non-verbal embodiments.

The mobile animated virtual coach was used in several short user experiments with the Smarcos architecture, as well as with the decentralized coaching platform developed at Roessing Research and Development [34].

In the second, a 'long-term' user evaluation Smarcos system was continuously evaluation by office workers during the six weeks period.

1) Subjects: Long-term Evaluation of Smarcos Coaching System: Participants were asked to join the user evaluation by email, social media and face-to-face communication. Participants had to be office workers (sedentary profession) and had to own an Android smartphone with an operating system Android version 2.3 or higher. Sixty office workers indicated they are willing to join the experiment. Participants were randomly assigned to one of the three groups: one group (N=19) received feedback as text (text group: TXT), a second group (N=15) received feedback by a virtual human coach represented as an embodied conversational agent (embodied conversational agent group: ECA). A third control group (N=9) did not receive feedback message on the smart phone. Participants of the control group could only get feedback via the web portal. The distribution over the three groups was random, but participants needed to meet some requirements to be selected for the ECA group. The inclusion criteria for the embodied conversational agent group was the ability to buy a Dutch text-to-speech engine from the Google Play store.

2) Procedure: Long-term Evaluation of Smarcos Coaching System: The duration of the complete evaluation was seven weeks. This included one assessment week at the start of the user evaluation. Before the start of the evaluation each participant was visited at home or at the office. The participants were required to own a smartphone with Android 2.3 or higher. Each participant received the activity sensor and an information sheet with details about the user evaluation. The goal of the study and the procedure was discussed. After reading all the information material and making sure no questions were left, participant had to sign two copies of the consent form (one for the participant and one for the researcher). Software, applications for the smartphone, user manuals about the installation of software and links to questionnaire were provided via email.

It was explained that the first week was an assessment week in order to establish their normal activity level to tailor the system and generate a personal goal. During the assessment week no feedback messages were given by the system. After the assessment week participants received their personal goals and used the system for six weeks. In these six weeks feedback (updates, requests, reminders and overviews) about their progress was provided. Participants were asked to upload their activity data at least one time per day by connecting their activity monitor to their computer. Halfway the evaluation the system offers users how over or under performed in the first three weeks a new (higher or lower) goal. Participants were free to accept this new goal.

Participants were asked to fill in three questionnaires during the evaluation. One in the first week (assessment week), one after the third week and one after the sixth week. Questionnaires were available online and participants received an email when it was time to fill in a questionnaire including a link to access the questionnaire. Shortly after the evaluation the participant was visited again to collect the materials. During this visit the participant was invited for a post-interview to discuss their experiences. This interview was voluntarily.

3) Results: Long-term Evaluation of Smarcos Coaching System: Forty three participants completed the user evaluation by finishing the assessment week, using the system for at least six weeks and completed all the questionnaires. Participants were between 21 and 57 years old, and worked 36,1 hours per week on average. All participants except two owned an Android smartphone. Those two participants were included in control group. All the participants were familiar with mobile internet, 26 subjects indicated to have very much experience with mobile internet, eleven participants indicated to have much experience and four participants indicated to have less experience with mobile internet. Most of the participants do sports, 35 indicated to do sports every week for more than one hour, five indicated to do sports every week for less than one hour and four participants indicated not to do sport. All participants, except one, were not familiar with behavior change support systems at all. One participant (from the control group) indicated to have a lot of experience with behavior change support systems.

All the participants of the user evaluation were invited for a semi-structured post-interview to discuss the system and their experiences during the user evaluation. Twenty-one participants accepted the invitation (text group: ten participants, virtual human group: ten participants, control group: one participant). During the interviews we asked the participants about their general impression (good and bad experiences), problems they have experienced during the evaluation, if they think that such a coaching system could help people to be more physical active, if they should recommend the system to others and the two different ways of presenting feedback were discussed. At the end there was some time left to discuss other remarks from the participants. During the post-interview, participants were asked about their general impression of the coaching system and their own experiences while using the Smarcos system. Other questions included: awareness on the amount of physical activity; content and visual representation of the feedback (text based / virtual human based); usefulness of the system regarding motivation to live a healthier life; recommendation regarding further use of the system and general remarks.

Interviews were transcribed and additional data analysis was carried out in order to identify the persuasive features according to the persuasive system design model [39]. It was important to identify which persuasive features might influence the response of participants regarding their experience with using the personal coaching system. Several crucial persuasive features were identified and categorized into (1) *stimulating*: features that are perceived as having positive influence on motivating the user, perceived usefulness and adherence, (2) *blocking*: features that are perceived as having a negative influence on motivating the user, perceived usefulness and adherence, and (3) *neutral* features that are perceived as having no effect on motivating the user, perceived usefulness and adherence. Table I presents the stimulating features and quotes from participants. Table II gives an overview of the stimulating persuasive features that should be improved.

Next to the features presented in both tables, several other important design factors have been identified based on the extra interview data analysis. First, not only personal feedback is important to motivate users, but also the *timing* of the *feedback* messages on personal goals (achieved yet or not, encouragement to continue): *"No, the timing of the feedback is wrong. You should be able to have more control over the system and your data."*; *"Feedback (timing and content) is predictable. Feedback should be more targeted and timing is important."*Ṡecond, the *'fun'* factor was mentioned several times as an important feature influencing the motivation of the users and interactivity with the personal coach: *"For myself it was fun to use and I would buy the system. It is good to motivate people to be more physical active."*

TABLE I: RESULTS LONG-TERM EVALUATION PERSONAL COACHING: *STIMULATING* PERSUASIVE FEATURES

Persuasive feature	Quote
Self-monitoring	*"It is nice to see your daily score of physical activity and week overviews." (text group)*
Social role	*"The system (virtual human coach) is like an external motivation to be more physically active."*
Praise	*"It was nice to receive feedback about your own behavior, also on the sensor itself." (text group)*
Liking	*"I think a virtual human will be more fun. Text is static and open for multiple interpretations. A virtual human can help to present the right interpretation by showing some empathy." (virtual human group)*
Similarity	*"The virtual human will add some social pressure to the feedback." (virtual human group)*

TABLE II: RESULTS LONG-TERM EVALUATION PERSONAL COACHING: *STIMULATING* PERSUASIVE FEATURES TO IMPROVE ON

Persuasive feature	Quote
Tailoring	*"Feedback (timing and content) is predictable. Feedback should be more targeted and timing is important. (virtual human group)"*
Personalization	*"I want to have more control over my goals. It is my goal and not the goal of the system. Goals can change day by day.. (text group)"*

Results of a six weeks user evaluation with the physical activity coaching system show that Physical Activity Level (PAL) values do not differ between the ECA and TXT condition. Thus feedback by means of an ECA has no added value over feedback by means of a text message if we look at the target objective. The control group that did not receive feedback and no reminders to upload their sensor data performed worse compared to both ECA and TXT group. In particular, in the control group the mean of the PAL values dropped from week 4 onwards. We used a Mann-Whitney U test to compare the results between the different groups. At the end of week 6 the PAL level of the ECA group wa significantly less than the mean for the TXT group $((Mdn = 1,61), U = 36,00, p = 0,014, r = -0,460)$. The number of uploads of PAL data in the control group was significantly less than in the TXT group during all six weeks $((Mdn = 3,00), U = 51,00, p = 0,045, r = 0,378)$.

Interviews and questionnaires reveal that on smartphones users prefer glanceable presentation of feedback messages.

Reading the short text message is faster than listening to the spoken message. Smart phones are for quick access and glanceable presentation of feedback fits the message and the use context. In line with the conclusions of Lisetti et al. [40], we believe that the opportunities offered by the technology of animated conversational characters are exploited fully in multi-modal spoken personalised emphatic dialogs with the user. The user evaluations reported by Lisetti et al. had a similar objective as but the research methods differ in a number of ways. The most important is that Lisetti applied a lab user test. whereas our study included a real-life evaluation. A second important difference is that our ECA platform is based on the BML framework and runs on mobile platforms. This offers new opportunities for coaching systems in clinical applications.

A cross media or multi-device coaching system can support the execution of an intervention program in which a team of human and virtual coaches work towards a negotiated goal, or to sustain a certain lifestyle. Such a blended format combining virtual coaching with real-world coaching is a novelty in HCI design.

IV. User Evaluations: Persuasive Design Factors for eHealth and Social Media Apps

Sexual health is a specific sensitive subject in many cultures and there is little research on the effects of prevention-focused interventions in this domain. The exploratory user study aimed at identifying the design features interventions have to possess to facilitate qualitatively well-designed and tailored eHealth interventions in the future and to evaluate currently available ones. We investigated which design factors are important using focus group discussions with high-risk adolescents. The user study focused on social media, serious games, mobile applications and the use of personal virtual coaching for lifestyle support (see Fig. 2). Primary research question was which persuasive design factors influence the use and adoption of various eHealth interventions in public sexual health services.

Participants explored and gave feedback on a number of existing and new social media applications and modern media applications in a focus group setting. All sessions were audio recorded with participants permission.

Participants were also asked to express their opinion about the three new concepts for new media applications integrated in modern social media, namely, (i) a serious game embedded in the existing social network, e.g., Facebook, (ii) a mobile application functionality embedded in Facebook, and (iii) a personal virtual coach embedded in either a social network, a website or a mobile application. Each concept represented certain persuasive features, which were discussed using clear visual examples without explicitly naming which persuasive feature was represented.

In the last part, adolescents shared their own ideas and tips about promoting public sexual health services and healthy lifestyle via eHealth applications and social media. The script, the power point slides and the duration of various parts of the focus group session were first tested during a pilot session and adjusted based on the outcome. An assistant took notes and answered questions about the group assignments.

During the data analysis, audio files were fully transcribed, analyzed, coded and categorized. The persuasive features have been coded according to the persuasive system design model [39]. An analysis of the influence of persuasive features on the response of adolescents towards various types of presented media was done.

A. Result of the Focus Group Study

In total, thirty seven young adults with low socio-economical and various ethnical backgrounds (51, 4% male and 48,6% female) participated in four focus group discussions. Participants are considered as having ethnic origin in case if at least one parent is born in a different country. Participants were between 12 and 24 years old (M=17,4 SD=3,1), and owned a mobile phone. Thirty four out of thirty seven participants had internet access at home, and thirty two participants had mobile internet access. From the thirty seven adolescents who participated in a focus group study, 89,2% participants were low-educated. All participants indicated they use social media daily. Most popular social media among adolescents were Facebook (27), Twitter (15), Instagram (20). WhatsApp and Youtube are also popular.

The results of the focus group study showed that adolescents have positive attitude towards the use of a personal virtual coach for health promotion, as long as they perceive there is a real human behind the virtual character. Several important persuasive features were identified during the data analysis. The identified features were categorized into (1) *stimulating*: features that are perceived as having positive influence on motivating the user, perceived usefulness and adherence, (2) *blocking*: features that are perceived as having a negative influence on motivating the user, perceived usefulness and adherence, and (3) *neutral* features that are perceived as having no effect on motivating the user, perceived usefulness and adherence. Table III presents the stimulating features and quotes from participants. Table IV presents the blocking feature and quotes from the focus group study.

TABLE III: RESULTS FOCUS GROUP STUDY: *STIMULATING* PERSUASIVE FEATURES

Persuasive feature	Quote
Trustworthiness	*"I would use the coach if the answers are reliable."*
Expertise	*"I would like it (virtual coach) to be made by someone who has the experience."*
Liking	*"Mostly if it looks nice, you are more likely to play with it (serious game)."*
Tunneling	*"If you just look on the Internet, for instance stuff about sex, lots of things come up. With the app it is much easier."*

TABLE IV: RESULTS FOCUS GROUP STUDY: *BLOCKING* PERSUASIVE FEATURES

Persuasive feature	Quote
Recognition	*"I really don't want anyone to know that I have been using this app (personal coach on facebook)."*

Based on the identified persuasive features, the following important design factors were formulated. *Anonymity* was found as the most important factor, which has important

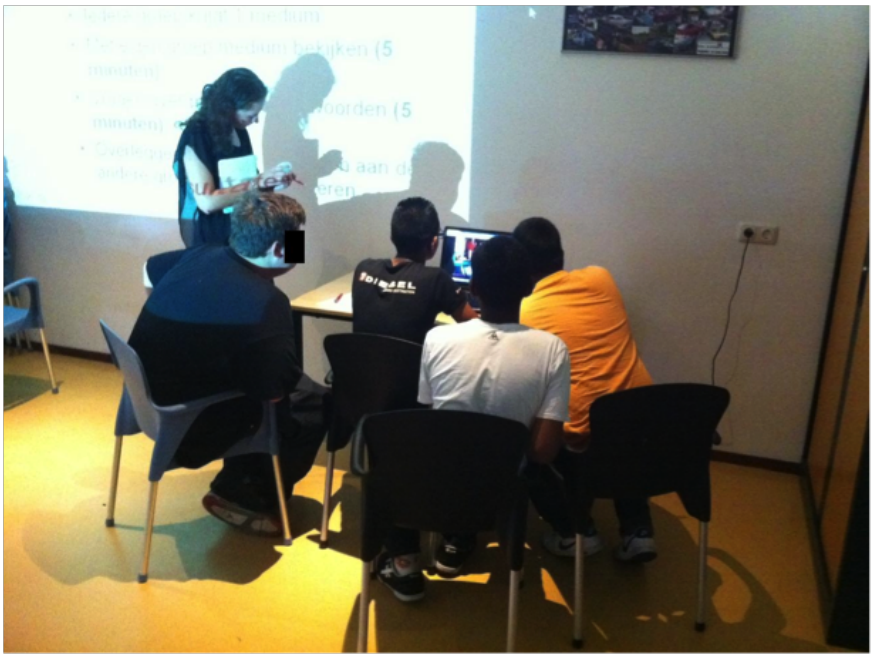

Figure 2: Focus group session: subgroup task where participants explore a serious game [1]. Picture was taken with participants' permission.

implications for the use of social networks for sexual well-being enhancement. Social media networks lack privacy and therefore eHealth applications, for example on Facebook, are not a recommended media for enhancing sexual well-being of high-risk adolescents. Instead, social networks can be used to increase the familiarity of the target group with the existing interventions. The next factor, level of *interactivity* was identified as indispensable. Serious games and mobile applications are expected to have a high level of interactivity to better engage users and thus increase uptake of lifestyle interventions. The type of platform the eHealth technology is realized on was another essential factor. Personal mobile devices, and smart phones in particular, were most preferred due to the high level of privacy and familiar user experience. In addition to the factors mentioned above, the *reliability* of the information *source* was clearly an important issue across all media types. Participants stated the importance of the clear visibility of the information source, as well as the logo or the name of the health organization behind the intervention. Another factor, namely, *support* for *visual aids*, was also identified across all types of applications. Specific to adolescents with low socio-economical background, lifestyle change support systems have to be more visually aided. The language use in the content has to be simple, low threshold and preferably in several languages to reach various ethnic groups. Applying these factors in the design of eHealth technologies for lifestyle support should increase their uptake and usefulness for enhancing well-being of high-risk adolescents and contribute to healthier lifestyle.

V. Lessons Learned: Design Guidelines for Personal Coaching and Lifestyle Support

What have we learned from studies about the effects of a virtual coach in lifestyle coaching systems? In general, user studies showed positive attitude towards the use of a virtual coach for lifestyle change support. Several stimulating persuasive features were identified in both studies. One persuasive feature *liking* overlaps. Visual appeal is a crucial design factor as it determines whether a user is will get motivated to start with the lifestyle behavior change program. Various visual aids and user-centered design methods can ensure that visual representations of the interface are appealing to the target user group. Personal tailoring plays an important role here, as one of the participants stated even variation in how the virtual coach looks like is desirable: *"I think it is more human like to receive a feedback message from a virtual human, but these messages need to be less predictable. Messages should be a kind of surprise (change the appearance of the virtual human every now and then)"*. This feature can be easily enabled by allowing user to choose from various avatars with different appearances and even different voices for the virtual coach.

Motivation is another important factor when it comes to the willingness to use a particular lifestyle coaching system. It makes a difference if an eHealth intervention is supported by a real human healthcare professional. Effective coaching and *tailored feedback* in terms of its *timing*, content and interaction design are crucial elements in affecting behavioral change. The next generation of the lifestyle coaching systems will be able to predict the optimal timing for providing feedback by analyzing previously given feedback messages. A *personal target goal* has to be challenging and reachable, step by step, within a set period of time.

Users prefer to be *in control* of how, when (right timing) and on what device they want to receive personal feedback from a virtual coach. Feedback messages have to offer enough *variation* so that the users stay motivated. In addition, we learned that users want to monitor their history and progress:

what they have done and what they should do next. They expect a connection between the personal goal-setting features for behavioral change and the personal coach to provide visual feedback.

Next lesson is the need to provide personalized (tailored) feedback: show *progress towards target*, adjust target, motivate, *suggest actions*, provide real time information. In addition, fun element has to be integrated in user interface to make interaction with the coach more playful. Users get bored by same messages and standard feedback. Variety in output modalities can facilitate this by providing user the choice to set the feedback presentation mode him/herself: text-based / virtual human and speech / light, etc. Facilitating navigation through information that user needs is also found important, for example by offering a user to search information by *alternative interaction modalities* such as speech input. However, the coach should not talk to the user when the head phone is unplugged. Therefore, a context-sensitive smart sensors technology is needed to enable this feature.

Online coaching also needs to be better integrated with offline feedback to stimulate the participation and commitment of the user to a lifestyle change support program [41]. Combining real-time usage behavior data with personalized virtual coaching and timely *persuasive feedback* can contribute to higher engagement and better uptake of lifestyle change support system by patients as well as healthcare professionals.

A. Challenges in Evaluating Lifestyle Change Support Systems

Evaluating lifestyle change support systems remains an ongoing challenge [31]. One of the main future challenges in evaluation of eHealth technology in general [11] is developing a mixed methods approach and standards for evaluating the effects of eHealth from a user perspective [6][9]. Validated instruments for user evaluations are needed to measure the effects of personalized eHealth interventions, such as changes in lifestyle or other behavior change [30]. The field of eHealth technology and telemedicine can benefit from adopting design and evaluation methods from the field of HCI. Professionals from the field of health and social psychology, and potential end users should be involved not only in the design and effects evaluation of eHealth applications for lifestyle support, but also in the iterative process evaluation of these applications. Health professionals and social scientists could augment about the effectiveness of the content of a persuasive message, and end users could provide feedback for constant improvements of the applications. Researchers and experts from the field of human computer interaction could play a vital role in better designing and evaluating persuasive features of the technology [31].

HCI evaluation methods are well suited for the short-term user evaluation to measure the effects of intervention before the long-term implementation. Naturally, HCI evaluation methods need to be adjusted to the specific goal of the eHealth technology and multi-device lifestyle support systems in particular [32]. In return, HCI field can benefit from the active logging methods and eHealth techniques for analyzing usage behavior patterns for better tailoring of personalized feedback [10][11][42]. In addition, psychological and motivational factors need to be incorporated into HCI evaluation techniques and measurements in order to identify how these factors influence the uptake and use of technology for lifestyle support.

VI. Conclusion and Future Work

Applying user-centered design techniques can significantly improve the appeal of the user interface and thus the engagement with personal lifestyle coaching system [32]. Next to the ease-of-use, visual appeal and clear presentation, the user experience has to be enjoyable and rewarding. Active engagement of the user in interaction with lifestyle intervention is crucial to ensure prolonged use of an intervention.

There is a need for guidelines and standardization for evaluation of eHealth technology in general [11], as well as for the lifestyle support systems, in particular. In addition, the multi-device architecture is necessary to enable easy exchange of monitoring data between web-based and private mobile parts of lifestyle support systems. Qualitative evaluation studies focusing on the process evaluation and user experiences with technology can help researchers to understand what persuasive features can enhance adherence, motivate people and how this technology should be further developed to optimally match the final design with the needs of real users in daily healthcare practice. This paper combines methods from HCI and eHealth and makes several contributions: (1) new insights into the existing lifestyle change support systems with personal virtual coaching, their limitations and recommendations for improvements (lack of unanimity in interface and interaction, etc.); (2) integrated approach by considering a multi-device eHealth system with motivational design features (such as timely feedback), which increases the involvement of patients as well as healthcare professionals and (3) practical recommendations for persuasive design and evaluation methodology combining validated and widely used methods from eHealth and HCI fields.

To conclude, lifestyle behavior support systems need to be be evaluated throughout all stages of the eHealth technology development cycle. Furthermore, it is also essential to evaluate the effects of eHealth interventions that have already been disseminated, using multidisciplinary approach and by independent evaluators.

VII. Acknowledgments

We thank all participants of the focus groups and other user studies, Municipal Health Services and social workers. Special thanks are due to Irina Lehmann and Cristel Boom for assistance in recruitment and data analysis. Part of the work presented is funded by the EU, within the framework of the ARTEMIS JU SP8 SMARCOS project 100249. Focus group study is a part of Sense eHealth project funded by the Ministry of Health, Welfare and Sport (VWS) and is carried out in collaboration with the Dutch National Institute for Public Health and Environment (RIVM).

References

[1] O. Kulyk, R. op den Akker, R. Klaassen, and J. van Gemert-Pijnen, "Let us get real! integrated approach for virtual coaching and real-time activity monitoring in lifestyle change support systems," in Proceedings of the International Conference on eHealth, Telemedicine, and Social Medicine (eTELEMED'14). IARIA, 2014, pp. 211–216.

[2] F. Yekeh and J. Kay, "Hypothesis evaluation based on ubicomp sensing: Moving from researchers to users," in Persuasive'13, ser. CEUR Workshop Proceedings, S. Berkovsky and J. Freyne, Eds., vol. 973, 2013.

[3] T. W. Bickmore, D. Schulman, and C. Sidner, "Automated interventions for multiple health behaviors using conversational agents," Patient education and counseling, vol. 92(2), August 2013, pp. 142–148.

[4] T. W. Bickmore, L. Caruso, and K. Clough-Gorr, "Acceptance and usability of a relational agent interface by urban older adults," in ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'05). New York, NY, USA: ACM, 2005, pp. 1212–1215.

[5] H. op den Akker, M. Tabak, M. Marin-Perianu, R. Huis in 't Veld, D. V. M. Jones, D. Hofs, T. M. Tönis, B. W. van Schooten, P. M. M. Vollenbroek-Hutten, and P. H. J. Hermens, "Development and evaluation of a sensor-based system for remote monitoring and treatment of chronic diseases - the continuous care & coaching platform," in 6th International Symposium on eHealth Services and Technologies, EHST 2012. Portugal: SciTePress - Science and Technology Publications, July 2012, pp. 19–27. [Online]. Available: http://doc.utwente.nl/83432/ [retrieved: Nov 30, 2014]

[6] L. Van Velsen, N. Nijhof, and O. Kulyk, "Health 2.0 emerging technologies," in Improving eHealth, J. van Gemert-Pijnen, O. Petersen, and H. Ossebaard, Eds. Boom Publishers, den Haag, The Netherlands, 2013, pp. 111–126.

[7] S. Ananthanarayan and K. Siek, "Persuasive wearable technology design for health and wellness," in 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth'12), 2012, pp. 236–240.

[8] N. Nijland, "Grounding ehealth: towards a holistic framework for sustainable ehealth technologies," Ph.D. dissertation, University of Twente, Enschede, the Netherlands, January 2011. [Online]. Available: http://doc.utwente.nl/75576/ [retrieved: Nov 30, 2014]

[9] E. J. van Gemert-Pijnen, N. Nijland, M. van Limburg, C. H. Ossebaard, M. S. Kelders, G. Eysenbach, and R. E. Seydel, "A holistic framework to improve the uptake and impact of ehealth technologies," J Med Internet Res, vol. 13, no. 4, Dec 2011, p. e111. [Online]. Available: http://www.ncbi.nlm.nih.gov/pubmed/22155738 [retrieved: Nov 30, 2014]

[10] M. S. Kelders, E. J. Van Gemert-Pijnen, A. Werkman, N. Nijland, and R. E. Seydel, "Effectiveness of a web-based intervention aimed at healthy dietary and physical activity behavior: A randomized controlled trial about users and usage," J Med Internet Res, vol. 13, no. 2, Apr 2011, p. e32.

[11] K. D. Ahern, M. J. Kreslake, and M. J. Phalen, "What is ehealth (6): Perspectives on the evolution of ehealth research," J Med Internet Res, vol. 8, no. 1, Mar 2006, p. e4.

[12] H. Oinas-Kukkonen and M. Harjumaa, "Persuasive systems design: Key issues, process model, and system features," Communications of the Association for Information Systems, vol. 24, no. 1, 2009, p. 28.

[13] S. Pingree, R. Hawkins, T. Baker, L. duBenske, L. Roberts, and D. Gustafson, "The value of theory for enhancing and understanding e-health interventions," American journal of preventive medicine, vol. 38(1), 2010, pp. 103–109.

[14] H. Oh, C. Rizo, M. Enkin, and A. Jadad, "What is ehealth (3): A systematic review of published definitions," J Med Internet Res, vol. 7, no. 1, Feb 2005, p. e1.

[15] A. Black, J. Car, C. Pagliari, C. Anandan, and K. e. a. Cresswell, "The impact of ehealth on the quality and safety of health care: A systematic overview," PLoS Med, vol. 8(1), 2011, e1000387. doi:10.1371/journal.pmed.1000387 [retrieved: Nov 30, 2014].

[16] S. Consolvo, P. Klasnja, D. W. McDonald, D. Avrahami, J. Froehlich, L. LeGrand, R. Libby, K. Mosher, and J. A. Landay, "Flowers or a robot army?: Encouraging awareness & activity with personal, mobile displays," in Proceedings of the 10th International Conference on Ubiquitous Computing, ser. UbiComp '08. New York, NY, USA: ACM, 2008, pp. 54–63.

[17] S. A. Clemes and R. A. Parker, "Increasing our understanding of reactivity to pedometers in adults," Medicine & Science in Sports & Exercise, 2009.

[18] H. op den Akker, V. M. Jones, and H. J. Hermens, "Tailoring real-time physical activity coaching systems: a literature survey and model," User Modeling and User-Adapted Interaction (available online), 2014.

[19] M. Kasza, V. Szucs, A. Vegh, and T. Torok, "Passive vs. active measurement: The role of smart sensors," in The Fifth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, 2011.

[20] H. op den Akker, R. Klaassen, R. op den Akker, V. Jones, and H. Hermens, "Opportunities for smart and tailored activity coaching," in Proceedings of the 26th International Symposium on Computer-Based Medical Systems (CBMS2013). USA: IEEE Computer Society, 2013, pp. 546–547, iSBN=978-1-4799-1053-3.

[21] W. Brouwer, A. Oenema, R. Crutzen, J. de Nooijer, N. de Vries, and J. Brug, "An exploration of factors related to dissemination of and exposure to internet-delivered behavior change interventions aimed at adults: A delphi study approach," J Med Internet Res, vol. 10(2):e10, 2008.

[22] J. Fanning, P. S. Mullen, and E. McAuley, "Increasing physical activity with mobile devices: A meta-analysis," J Med Internet Res, vol. 14 (6), Nov 2012, p. e161.

[23] L. Dennison, L. Morrison, G. Conway, and L. Yardley, "Opportunities and challenges for smartphone applications in supporting health behavior change: Qualitative study," J Med Internet Res, vol. 15, no. 4, Apr 2013, p. e86.

[24] S. Bosch, M. Marin-Perianu, R. Marin-Perianu, P. Havinga, and H. Hermens, "Keep on moving! activity monitoring and stimulation using wireless sensor networks," in Smart Sensing and Context, ser. Lecture Notes in Computer Science, P. Barnaghi, K. Moessner, M. Presser, and S. Meissner, Eds. Springer Berlin / Heidelberg, 2009, vol. 5741, pp. 11–23.

[25] T. Baranowski and L. Frankel, "Let's get technical! gaming and technology for weight control and health promotion in children," Childhood Obesity, vol. 8(1), 2012, pp. 34–37.

[26] S. Deterding, "Gamification: Designing for motivation," Interactions, vol. 19, no. 4, 2012, pp. 14–17. [Online]. Available: http://doi.acm.org/10.1145/2212877.2212883 [retrieved: Nov 30, 2014]

[27] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining 'gamification'," in Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, ser. MindTrek '11. New York, NY, USA: ACM, 2011, pp. 9–15. [Online]. Available: http://doi.acm.org/10.1145/2181037.2181040 [retrieved: Nov 30, 2014]

[28] W. Kamin and A. Kreplin, "Teaching the inhalation manoeuvre to asthmatic children by means of visual feedback," Pneumologie, vol. 61(3), 2007, pp. 150–156.

[29] H. Kharrazi, A. Faiola, and J. Defazio, "Healthcare game design: Behavioral modeling of serious gaming design for children with chronic diseases," in Proceedings of the 13th International Conference on Human-Computer Interaction. Part IV: Interacting in Various Application Domains. Berlin, Heidelberg: Springer-Verlag, 2009, pp. 335–344.

[30] P. Klasnja, S. Consolvo, and W. Pratt, "How to evaluate technologies for health behavior change in hci research," in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ser. CHI '11. New York, NY, USA: ACM, 2011, pp. 3063–3072.

[31] S. Lanfrial, "From digital interventions to behavior change support systems: Understanding persuasive systems development and evaluation of process behavior change technologies," in Proceedings of IRIS 2012, 2012, pp. 1–16.

[32] J. Scholtz and S. Consolvo, "Toward a framework for evaluating ubiquitous computing applications," IEEE Pervasive Computing, vol. 3, 2004, pp. 82–88.

[33] B. Fogg, "A behavior model for persuasive design," in Proceedings of the 4th International Conference on Persuasive Technology, ser. Persuasive '09. New York, NY, USA: ACM, 2009, pp. 40:1–40:7. [Online]. Available: http://doi.acm.org/10.1145/1541948.1541999 [retrieved: Nov 30, 2014]

[34] R. op den Akker, R. Klaassen, T. Lavrysen, G. Geleijnse, A. van Halteren, H. Schwietert, and M. van der Hout, "A personal context-aware multi-device coaching service that supports a healthy lifestyle," in Proceedings of the 25th BCS Conference on Human-Computer Interaction, ser. BCS-HCI '11. Swinton, UK, UK: British Computer Society, 2011, pp. 443–448. [Online]. Available:

http://dl.acm.org/citation.cfm?id=2305316.2305397 [retrieved: Nov 30, 2014]

[35] H. op den Akker, M. Tabak, M. Marin-Perianu, M. H. A. Huis in 't Veld, V. M. Jones, D. H. W. Hofs, T. M. Tönis, B. W. van Schooten, M. M. R. Vollenbroek-Hutten, and H. J. Hermens, "Development and evaluation of a sensor-based system for remote monitoring and treatment of chronic diseases - the continuous care & coaching platform," in Proceedings of the 6th International Symposium on eHealth Services and Technologies, EHST 2012, Geneva, Switzerland. Portugal: SciTePress - Science and Technology Publications, July 2012, pp. 19–27.

[36] R. Klaassen, R. op den Akker, and H. op den Akker, "Feedback presentation for mobile personalised digital physical activity coaching platforms," in Proceedings of the 6th International Conference on Pervasive Technologies Related to Assistive Environments, ser. PETRA '13. New York, NY, USA: ACM, 2013, pp. 64:1–64:8. [Online]. Available: http://doi.acm.org/10.1145/2504335.2504404 [retrieved: Nov 30, 2014]

[37] R. Klaassen, J. Hendrix, D. Reidsma, R. op den Akker, B. Dijk, and H. op den Akker, "Elckerlyc goes mobile-enabling natural interaction in mobile user interfaces," International journal on advances in telecommunications, vol. 6 (1-2), 2013, pp. 45–56.

[38] H. Vilhjalmsson, N. Cantelmo, J. Cassell, N. E. Chafai, M. Kipp, S. Kopp, M. Mancini, S. Marsella, A. N. Marshall, C. Pelachaud, Z. Ruttkay, K. R. Thorisson, H. van Welbergen, and R. J. van der Werf, "The behavior markup language: Recent developments and challenges," in Intelligent Virtual Agents, ser. LNCS, C. Pelachaud, J.-C. Martin, E. Andre, G. Collet, K. Karpouzis, and D. Pele, Eds., vol. 4722. Berlin, Heidelberg: Springer-Verlag, 2007, pp. 99–111.

[39] H. Oinas-Kukkonen and M. Harjumaa, "Persuasive systems design: Key issues, process model, and system features," Communications of the Association for Information Systems, vol. 24(28), 2009.

[40] C. Lisetti, R. Amini, U. Yasavur, and N. Rishe, "I can help you change! an empathic virtual agent delivers behavior change health interventions," ACM Trans. Manage. Inf. Syst., vol. 4, no. 4, Dec. 2013, pp. 19:1–19:28.

[41] J. Freyne, I. Saunders, E. Brindal, S. Berkovsky, and G. S. 0003, "Factors associated with persistent participation in an online diet intervention." in Extended Abstracts of the ACM Annual Conference on Human Factors in Computing Systems, 2012, J. A. Konstan, E. H. Chi, and K. Höök, Eds. ACM, 2012, pp. 2375–2380.

[42] A. Barak, L. Hen, M. Boniel-Nissim, and N. Shapira, "A comprehensive review and a meta-analysis of the effectiveness of internet-based psychotherapeutic interventions," Journal of Technology in Human Services, vol. 26(2-4), 2008, pp. 109–160.