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The STAR-C Intelligent Coach: A Cross-Disciplinary Design Process of a Behavior Change Intervention in Primary Care

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Abstract. A broad range of aspects are needed to be taken into consideration in the design and development of personalized coaching systems based on artificial intelligence methodologies. This research presents the initial phase of joining different professional and stakeholder perspectives on behavior change technologies into a flexible design proposal for a digital coaching system. The diversity and sometimes opposed views on content, behavior, purposes and context were managed using a structured argument-based design approach, which also feed into the behavior of the personalized system. Results include a set of personalization strategies that will be further elaborated with the target user group to manage sensitive issues such as ethics, social norms, privacy, motivation, autonomy and social relatedness.

Keywords. personalization, behavior change, participatory action design, intelligent agents, cardiovascular diseases, argumentation theory, persuasive technology

Introduction

Chronic non-communicable diseases such as diabetes and cardio-vascular diseases (CVD) represent one of the major threats to health in today's society, where efficient strategies for prevention are still limited due to the complexity of supporting individuals in changing habits and unhealthy behaviors, e.g., sedentary behavior, poor nutrition, excessive alcohol consumption, smoking and stressful working and living conditions.

The Västerbotten Intervention Program (VIP), launched in 1985, is one of very few long-term CVD prevention programs in the world that 1) is integrated into routine primary health care settings; 2) targets all inhabitants the year they turn 40, 50, 60; and 3) combine low-risk population and high-risk individual strategies [1]. Almost 190 000 health examinations have been conducted in the VIP until 2019. Between 5500-7500 examinations take place every year. Program evaluation for the period 1990-2006 showed a significant reduction both in CVD mortality and total mortality, compared to the national Swedish trend in of similar ages [2]. However, at the same time it illustrated the need for further efforts. The individual health dialogue (conducted using motivational

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interviewing, MI) by nurses every tenth year was not designed to support individuals' choices on a day to day basis between health check-ups. Therefore, the interdisciplinary research program STAR-C[2] (Sustainable behavior change for health supported by person-Tailored, Adaptive, Risk-aware digital Coaching in a social context) aims at developing and evaluating a technical platform based on hybrid approaches of artificial intelligence (AI) encompassing the vast amount of VIP data including anthropometric measurements and self-reported survey data including self-rated health, personal health history and family history of CVD and diabetes, lifestyle habits, social network and diet. The platform will be used for providing personalized digital coaching to support the evaluation and maintenance of healthy behaviors, and behavioral change aimed at improving health as a complement to the interventions conducted by healthcare.

Behavior change systems aimed at improving health is a growing area of research, where vast proportion are aimed at non-communicable chronic conditions (e.g., [3]). Multi-component interventions seem to be more effective than stand-alone applications [4]. Yet, modest efficacy evidence of health applications has been seen in review studies [5], partly due to the complexity in human decision making and the related difficulties to achieve sustainable behavior change [5]. Moreover, there is a growing awareness that the AI-based systems that are expected to better address and help individuals to change behaviors, come with substantial ethical concerns, since personal data and private information is collected and used for building knowledge about individuals and groups of individuals [6].

This paper presents the first phase of the STAR-C program where experts in complementary fields have worked together to outline an initial design proposal taking ethical, cultural, social, personal, societal, medical and health aspects into account. Such aspects are typically not encompassed in the design and development of AI-based systems to be used by individuals in their private spheres, partly because there are no established methodologies on how this can or should be done [6].

1. Methods

A participatory action research methodology is applied for designing the AI-based coaching system throughout the STAR-C program [7], structured using an argumentation theory-based approach [8]. The methodology was chosen to encompass a broad range of potentially conflicting viewpoints on the purpose, content and behavior of the digital coach. Argumentation theory has also been formalized for the purpose to build AI-based systems that can manage conflicting information and information that may change over time (e.g., [9]). Non-monotonic reasoning methods such as answer set programming to manage conflicting arguments will also be further explored in this project.

In the first phase, ten experts in the field of epidemiology, nutrition, social psychology, social work, nursing, health economy, public health, and family medicine participated. The group included also healthcare professionals responsible for the VIP intervention. Unfortunately, the ethics expert initially engaged in the project was not available. The team leading the design process presented in this article included three researchers with expertise in AI, user experience design, human-computer interaction and medical informatics. All participants are involved in the STAR-C program.

[2] STAR-C Web page https://star-c.cs.umu.se/ Last accessed 11-May-2020

Open-ended in-depth interviews were conducted with each expert to explore views on and expectations from a digital coaching system for changing behaviors to improve health and for maintaining healthy lifestyles. Interviews were recorded and transcribed verbatim. Based on an initial analysis of the interviews, complementary and contradictory lines of approaches were identified, which formed the initial argument-based design alternatives. As a next step, the experts were divided into four groups based on their research interests, their visions and concerns. The groups were given a set of questions relating to the envisioned digital coaching system to discuss and tasks to do, such as to prioritize among targeted behaviors. The collected data was analyzed and formed into design arguments to identify conflicting views using the design rationale approach. The results were presented to the whole group to illustrate the diversity and commonalities in their visions and concerns and for the group to provide feedback. Some generic design choices were made, and generic key personalization strategies were identified based on which the personalization modules of the technical platform are built.

2. Results

The following five generic key personalization strategies were identified, which conform to design principles for behavior change systems defined in [10] (*tailoring, dialogue support, social support, credibility, self-monitoring, simulation of desired goals or connection between causes and effects*):

1. Multi-modally engaging goal setting
2. Embedded relevant evidence-based knowledge as base for generating personalized information about risks and, potentially fearful, facts
3. Personalization of the coach in the form of an avatar including its behavior
4. Assessment of progress in interaction with the user and personalized, interactive visualization of progress, or non-progress, feedback and rewards
5. Management of privacy including possibility to share content

These generic key personalization strategies provide complementary methods for adapting the application to the individual. Since it was emphasized that individuals will want to use the coaching application differently, the system needs to be flexible enough to change, depending on the user's preferences, changing goals, motivation, situation, view on how they want their health to be known to other people and by what they are motivated. Consequently, the design of the *user model* and the *dialogue support* is central for assessing these aspects across the personalization strategies. We illustrate our approach to manage personalization by an example in the following section.

2.1. Designing the STAR-C coaching platform

Modules that serve the personalization and adaptation purposes are being developed, and include: i) a graph-based knowledge repository, which includes information models of the user, the domain knowledge and an activity model, ii) a multi-agent platform, iii) a behavior change trajectory learning module and reasoner utilizing the VIP data, iv) a module for managing the user interfaces, and v) graphical user interfaces.

The personalization strategies and the targeted behaviors are treated as activities in terms of activity theory [11] to identify and formalize the motives, purpose, sub-tasks, criteria and intelligent agents that will be assigned responsibilities in the system. This

allows also for coordination at a higher level when negotiation and prioritization needs to be done to select personalization strategies in a situation. Key mechanisms for tailoring the software agents' behavior to the individual are the *tasks* and their priorities to be managed by the system (different sets of tasks are defined for each personalization strategy); the *roles* of each agent in the system (connected to responsibility for tasks and the individual's goals); and the *criteria* that put constraints on tasks.

Externally regulated motivation and trust may be enhanced through the digital coach, through monitoring, providing visualization of progress and non-progress, feedback and rewards, potentially as gamification. Making the use enjoyable, and providing a person-tailored and appealing avatar that brings the messages were proposed. To align with the envisioned coach in the form of an avatar, the coordinating agent is denoted the *coach agent*, and is the external representation of the agency of the system.

It is considered important to enhance the individual's own motivation to change behavior. Engagement and internal motivation could be enhanced through the possibility to engage in person-tailored goal setting through several modalities and senses, both cognitively and emotionally [12]. A challenge is to embed tailored support for managing conflicting goals and the needs that motivate goals and behaviors.

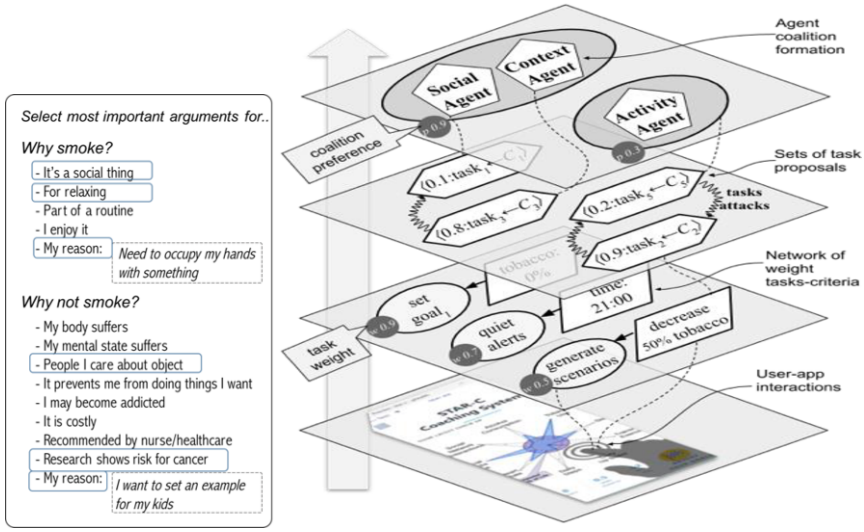

Figure 1. Example of motives for and against smoking on the left. On the right side, the generation of personalized, interactive visualization of progress and its constraints, and how the person can set a goal that the agents use for generating scenarios of potential effects.

An example of a prototype implementation is shown in Figure 1, where the generation of a personalized, interactive visualization of progress is exemplified as a star, similar to how the VIP assessment is visualized in clinical settings [1]. In our example, the user has selected *smoking* and *alcohol consumption* as two desired behaviors to change, each representing different parts of the star. An individual may have as goal to quit smoking, but an intermediate goal may be to reduce number of cigarettes to 50%, which the person suggests in our example. An analysis is made how this may be effectuated in practice (as scenarios) and presented to the person. Since the person's motive to smoke may be for social reasons and/or for relaxation, which could be same as for alcohol intake, the system may suggest different strategies depending on the

motives. The priorities between motives are weights associated to criteria for each task. Two tasks may be in conflict with each other, so that the agents need to agree on one of the tasks. One such conflict is the choice between not intruding during a social situation such as a dinner gathering, or intervene because it is a social situation, by providing the person a motivational message that reminds the person about his/her motives, in our example, to set an example for the children.

The individual's health risk perception, perceived susceptibility and self-efficacy may increase internal motivation to change health behaviors [14]. Examples mentioned were desire to avoid getting sick and information about risks. Characteristics mentioned that would contribute to building trust in the application were transparency and evidence-based knowledge content including adapted and tailored risk communication. To what extent a health coaching system would affect the externally regulated motivation by invoking fear versus hope to improve health in order to persuade the user to change behavior [15], raises ethical concerns that will be further explored with the targeted user group. This relates also to whether individuals want to use more fact-based or emotion-based arguments when reasoning about their health.

External motivation through societal visibility was discussed, such as posting information on social media. Diverse opinions were highlighted. On one hand, challenging others in physical activities, support groups, social comparison, peer / group pressure and encouragements could increase motivation, which is supported by earlier studies [3,4], and on the other hand, focusing on the individual without social comparison may be more successful in some individuals or situations. The visualization in the form of the star could progress over time, and be shared with a nurse or others.

Concerns were raised on how intrusive the application can be allowed to be, and to what extent individuals are actually willing to share information about progress or non-progress. On the other hand, a view was expressed that some individuals do share health information, potentially to greater extent if they see progress on a community level, e.g. a star with aggregated information from larger populations based on sub-communities in society. A common view was that knowledge is lacking, and further studies need to be conducted to investigate mechanisms of behavior change, privacy, social influence and the role of social media.

3. Discussion

The initial phase in co-creating a common view among a broad range of experts and stakeholders on how a personalized coaching application for preventing CVD can be designed is presented. The rich and many-faceted collective knowledge was providing broad insights and different, sometimes contradictory, viewpoints for design choices. The applied participatory action research, combined with argumentation-based design methodology to explore visions and expectations was found useful to allow the development of design rationale for different directions, and for combining these into personalization strategies. Moreover, the approach was also found useful to allow critiquing of features from an ethical, responsible AI design perspective. In particular, how autonomy, privacy, integrity, social norms and treatment of personal information can be seen from the different stakeholders' views.

The approach to co-create a common view through argument-based design rationale may allow more diversity in personalization, potentially also aligned with non-

monotonic approaches for the reasoning mechanisms in the systems. The example provided in this work will be further developed in future work.

4. Conclusions and Future Work

A participatory design process involving complementary professional views on AI-based coaching for behavior change generated a set of generic key personalization strategies. These strategies are expected to encompass a broad range of contradictory requirements to allow an AI-based coaching system to adapt its behavior to fulfil users' expectations and needs for privacy, social engagement, autonomy, knowledge and guidance in a process to maintain or change behavior for achieving better health.

Future work includes qualitative studies of attitudes on social media and its impact on behavior change and focus group studies with individuals participating in the VIP health checkups. The design proposals and prototypes will be further developed together with the participants and VIP nurses, and evaluated in the participatory design process. Diverse and opposed views on content, behavior, purposes and context will be managed using the structured argument-based design approach presented in this article, which also feed into the development of the adaptive behavior of the personalized system. Ongoing and future work includes also the generation of behavior change trajectories based on the VIP data, which can give person-tailored information to the individual on risks.

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