Lost in persuasion

A multidisciplinary approach for developing usable, effective, and reproducible persuasive technology for health promotion

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***Abstract*—Despite its acknowledged benefits for health promotion, the full potential of persuasive technology is not (yet) reached in regard to usability, effectiveness, and reproducibility. It often lacks an effective combination of technical features and behavior change strategies. This paper presents a multidisciplinary approach, addressing both aspects. It builds on the frameworks of situated Cognitive Engineering and Intervention Mapping. The approach generates building blocks from theory originating from different relevant disciplines; it specifies change objectives and requirements, described in the context of use, for intervention (strategy) and interaction (technology); it evaluates process, effect and impact, whereby claims on interaction and intervention are validated. To cope with language barriers between developers from different disciplines, the approach is presented as a guideline, illustrated with a case study. This approach is expected to contribute to a sound design rationale, a broad reach and ongoing use of the technology, and larger results in regard to health promotion.**

Keywords—system engineering, behaviour change, evaluation, usability, evidence-based intervention

I. Introduction

Persuasive technology is one of the potentially great contributions to ensure more personalized health, enabling and persuading people to take control of their own health, increasing timely support, and lowering contextual barriers. Also, it can potentially reduce the demand on existing (traditional) care facilities. Persuasive technology is considered a “class of technologies or interactive computing systems that are intentionally designed to change a person’s attitude or behavior” [1]. It is generally presented as websites, apps, and home automation applied in the context of eHealth. This technology aims to affect *determinants* of behaviour, such as attitude, beliefs and social norms and to improve the users’ intention to, for example, eat healthy, exercising regularly, stop smoking, and be medical adherent [2].

Changing behaviour takes time and effort and thrives under continuously detailed monitoring and personalized, social and contextualized feedback [3-4]. Contrary to human care, persuasive technologies have features, which can offer this support [1,5]. They can work around the clock and offer care to the user (e.g., patient)”at any moment”. They can offer anonymity, which may stimulate the user to be more open about his or her health condition. They can manage great amounts of data and use various modalities. Consequently, persuasive technologies can use significant numbers of information to provide recommendations and present them in the modality most comprehensible to the user. Also, these technologies are scalable and ubiquitous. Information is easily replicated and distributed through multiple devices in the user’s environment. They can also be shared with people in the user’s social environment, enabling social support. Finally, persuasive technologies can persuade and bring about behaviour change on multiple levels [6]. *Macro level persuasion* has an overall persuasive intent. In the context of health promotion, it concerns intervening on the target group to adopt healthy behaviours and thus improve their quality of life and health. *Micro level persuasion*, or *microsuasion*, aims at persuading the user to continue interaction with technology. This contributes to stimulating use until the desired behavioural change is reached.

Despite these benefits, the full potential of persuasive technology is not (yet) reached in regard to achieving lasting behaviour change. Persuasive technology is applied as ad-hoc, small-scale, and fragmentary initiatives, which lack robustness when it comes to long-term use. Specific challenges can be identified. First, the evidence-base for effectiveness of persuasive technology, in terms of health promoting behaviour, remains meagre [7]. Various randomized controlled trials (RCTs) examined the effectiveness of persuasive technologies in regard to health promoting behaviour, with a large variety in effectiveness. Multiple reviews show a positive, but moderate and short-term effect of computer- or web-based interventions on changing health promoting behaviour [8-10]. Second, persuasive technologies regularly lack a theory-based *design rationale*, i.e., argumentation for decisions made while designing the technology. The design is mainly based on earlier experiences, implicit expertise and heuristics. These more implicit forms of knowledge are relevant for the development of persuasive technology, but this only tells part of the story. Design also requires sound (scientific) foundation which shows what techniques are effective for engaging on certain determinants of behaviours [11-12]. Finally, these technologies reach a small range of users and, on top of that, they experience high levels of attrition. Numerous websites and apps are available, which make it challenging to bring a new persuasive technology under the target group’s attention. Once it has found its way to the target group, chances are that the

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technology is too generic and does not properly fit individual users' preferences and values, at the cost of their interest and motivation to use it [13]. To summarize, persuasive technologies generate modest results, lack a theory-based design rationale, have a selective reach and experience large drop-out rates.

To address these challenges, Mohr advocates that persuasive technology consists of an effective combination of technical features and behavior change *strategies* [11]. In turn, Crutzen promotes an approach, which integrates different frameworks and fields of science, or what he calls "the best of both worlds" [14]. Persuasive technology has its roots in the fields of behavioural and social sciences, psychology, cognitive engineering, and human-computer interaction (HCI). However, the existing frameworks are generally oriented towards one specific field, for example towards health promotion and psychology or towards system engineering and user interface design. Illustratively, the frameworks, such as Intervention mapping (IM) and the RE-AIM model offer approaches to determine which behaviour change technique or combination of techniques can be applied how within a (technology-supported) intervention, which effectively stimulates healthy behaviour [15-16]. In contrast, frameworks such as the persuasive system design model, situated Cognitive Engineering (sCE) method and Center for eHealth Research and Disease Management (CeHRes) roadmap offer a structured way to develop interactive, human-centred and usable persuasive systems [16-18]. The two types of frameworks can be mapped on the different levels of persuasion, mentioned earlier. Frameworks for intervention development fit with design of high level persuasion, whereas frameworks for interaction development fit better with low level persuasion.

These models, approaches and frameworks have shown their value in the designated field of science, i.e., research discipline, but also have their shortcomings, when it comes to developing effective, reproducible and usable persuasive technology [19]. Two specific studies illustrate this statement. Grolleman et al. applied IM to develop a virtual coach, which supported smokers during their attempt to quit. This exercise showed that previously proven behaviour change techniques can be translated to an internet-based intervention, but also that it goes at the cost of the flexibility of the intervention and thus at the usability [20]. However, the intervention treats everyone similar, to prevent high levels of design complexities, which in the end works for no one. Blanson Henkemans applied the sCE framework to develop a personal computer assistant, which supported people to maintain a healthier lifestyle and improve their health. This study showed that people experiences personal assistant user-friendly and stimulating. However, the personal assistant's effectiveness in real life is small and short-lasting [21].

The current paper presents a multidisciplinary approach for developing effective, reproducible and usable persuasive technology. The approach builds on two complementary frameworks. Primarily, on situated Cognitive Engineering (sCE), which consists of an iterative process of generation, specification, evaluation and refinement of cognitive functions of the technology [18]. These functions are incrementally included in this process, addressing the adaptive nature of both human and technology with their reciprocal dependencies, systematically. sCE provides guidance for developing the technical features of persuasive technology and, for guidance on the application of behavior change strategies, steps from Intervention Mapping (IM) are integrated [15]. This protocol for developing theory- and evidence-based interventions provides *needs assessment*, specification of behaviour *change objectives*, and application of the logic model for process, effect and impact *evaluation*.

The first aim of this paper is to offer an approach, which is based on frameworks covering both the technological features and behaviour change strategies and thus aids addressing the aforementioned challenges, hindering the full potential of persuasive technology. An important side-effect may occur when integrating multiple frameworks in one approach. As involved developers come from different disciplines, they often speak different jargons when it comes to development. This can lead to misunderstandings, at the cost of successful application of the proposed approach. The second aim is to aid bridging the language gap between different fields involved. The approach is presented as a guideline, which defines, explicates and illustrates the approach with a glossary and case study. This case study consists of a personal social robot for children aged 8-12 with diabetes, to aid them in coping with their illness [22].

II. A MULTIDISCIPLNED APPROACH FOR DEVELOPING PERSUASIVE TECHNOLOGY

Fig. 1 illustrates the proposed approach for developing persuasive technologies (see appendix for a glossary of key concepts), dealing with both technical features and behavior change strategies. It is based on sCE and selected steps of IM.

Intervention Mapping is a framework for developing and implementing health interventions and it may help to overcome this barrier [15]. Projects in the past show that IM allows developers to successfully: 1) identify behavioural and environmental determinants affecting target health problems and 2) select the most appropriate methods and strategies to address the identified determinants. It does so by focusing, on the one hand, on the end users of the and on contributing to their wellbeing. On the other hand, it focuses on intermediaries (such as caregivers and teachers) and on whether they apply the intervention as it has proven effective empirically.

The framework guides the developer though six iterative steps, which are:

1. Conducting a needs assessment: identifying the population, their health problems and/or quality of life, distinguishing environmental and behavioural causes and key determinants;
2. Developing programme *change objective matrices*: stating expected changes in behaviours and the environment, specifying performance objectives and determinants, differentiating the target population, and creating matrices of objectives and determinants;
3. Selecting theory-based intervention methods and practical strategies for behavioural and environmental

change: brainstorming methods, working up methods into strategies to address determinants, and organising strategies;

4. Producing programme components and materials for behavioural and environmental change: operationalising strategies and pretesting programme material with target groups and implementers;
5. Achieving programme adoption, implementation and maintenance: specifying adoption and implementation performance objectives, creating a matrix or planning schedule, and writing an implementation plan;
6. Evaluating the proposed programme: developing an evaluation model, studying *effect* and *process* evaluation outcomes, indicators and *measures*, and writing an evaluation plan.

In the health promotion field, Intervention Mapping has been successfully applied in various settings to a wide range of different behaviours and populations. It can help planners to develop theory- and evidence-based interventions to promote healthy behaviour.

Situated Cognitive Engineering (sCE) is a framework for developing cognitive systems, i.e., personal, adaptive and intelligent systems that support human performance in close collaboration in complex task environments [23]. The framework is based on practical theories and models originating from cognitive psychology and *human factors* and prescribes aspects that should be addressed during the development process. These aspects are divided across three iterative phases: foundation, specification and evaluation.

Generally speaking, developers first look at the foundation, consisting of *operational demands* for the system, the human factors that are at hand, and the technological *state-of-the-art* (SOTA). Based on this foundation, design specifications are derived, which consist of:

- *Design scenarios* and *use cases*, describing the context in which the user interacts with the system;
- *Requirements*, describing what the system should do;
- *Claims*, stating the hypothetical outcomes, when these requirements are met.

Finally, formative and summative evaluations are conducted, through review, simulations, and user experience evaluations. During the evaluation, the design outcome measures are analyzed.

sCE addresses Human-Computer Interaction issues related to users and the realization of complex and dynamic tasks and goals, in specific contexts, and with the use of certain tools. It has been proven effective for development of ICT support, which contribute to realizing performance objectives in different complex domains, such as on naval ships [24], space stations [25], and health promotion (e.g., performing self-management behavior) [21].

The multidisciplinary approach, based on sCE and IM covers three components: generation, specification and evaluation. The approach is iterative and the evaluation results provide implications for the refinement of the specifications.

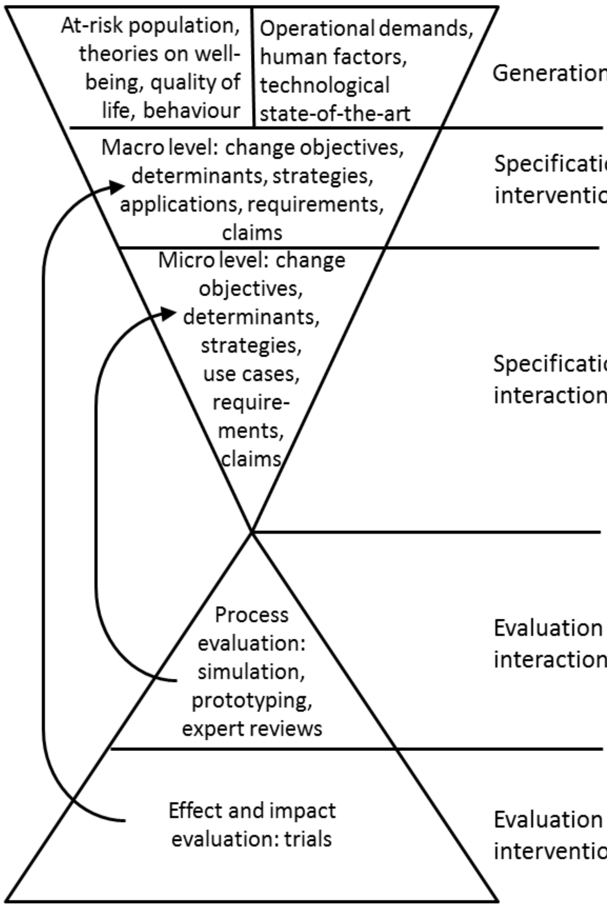

Fig. 1. Components of approach for developing persuasive technology

1) Generation*:* building of knowledge-base, encompassing epidemiology of the *at-risk population*, the operational demands, theories on well-being, quality of life, behaviour and human factors, and technological state-of-the-art;

2) Specification of persuasive intervention and interaction design: selecting evidence-based strategies and mapping them on change objectives at the level of a) behavioural health intervention (macro level persuasion) and b) interaction with technology (micro level persuasion); describing the design specifications through scenarios and requirements;

3) Evaluation of persuasive interaction and intervention: evaluating the interaction at the level of feasibility and efficacy (i.e. process evaluation); evaluating the intervention at the level of effectiveness and impact.

A. Generation

During generation, the building blocks for persuasive technology are collected. These blocks are health and operational needs, human factors and state-of-the-art. These blocks are collected through literature reviews, epidemiological investigations (mainly observational), work process analysis, and qualitative research (e.g., interviews, workshops).

Health needs consist of the well-being, quality of life and health conditions, for the at-risk population. The assessment relates to the discrepancy between the current conditions and the desired ones. The assessment also covers environmental and behavioural causes for the health problem, performance objectives to resolve these problems, and key determinants associated with these objectives. Operational demands (or operational needs) consists of work and/or activity conditions for the *actors* interacting with persuasive technology. They also cover the actors' work characteristics, roles, tasks and contexts. Human factors describe theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Finally, the SOTA, the highest level of general development of persuasive technology, provides insights in which technology (both hard- and software) are potentially applicable to facilitate the behaviour change interventions. An important characteristic of the SOTA is the so-called technology readiness level (TRL) of the technology considered. TRL is a measure used to assess the maturity of the current technology [26]. It ranges from level 1, basic principles observed and reported, through level 9, actual system 'flight proven' through successful mission operations. The TRL provides an indication in the investment required to come to full development of the proposed persuasive technology. Al these aspects need to be taken in mind, when setting specifications for both the persuasive technology and the health promoting intervention, as a whole.

B. Specification of intervention and interaction

Based on the generated building blocks, specifications are set for the intervention (macro level persuasion) and interaction (micro level persuasion). Specifications are essential to ensure technology is designed and programmed as intended. For both intervention and interaction, specifications cover change objectives, selected behaviour change techniques, and finally a description of the strategy. Change objectives are the most immediate target of an intervention and interaction. They are derived from change objective matrices that combine performance objectives with selected determinants. Tables I and II provide examples for change objectives for the intervention (macro level persuasion) and intervention (micro level persuasion).

TABLE I. CHANGE OBJECTIVE MATRIX FOR INTERVENTION

Performance objective	***Determinants (theory)***	***Change objective***
Monitor blood glucose	Health literacy (Integrated Theory of Health Behavior Change)	Explains how to perform monitoring
Inject insulin	Skills (general behaviour model)	Displays the ability to prick insulin
Cope with unusual situations	Self-efficacy (ASM-model)	Expresses the ability to cope with unusual situations
coping with unusual situations	Habit (behaviorism)	Automatically applies coping behaviour when faced with unusual situation without explicit decision making
Recognize symptoms	Social norm (theory of planned behavior)	Receives support from others to recognize symptoms

TABLE II. CHANGE OBJECTIVE MATRIX FOR INTERACTION

Performance objective	***Determinants (theory)***	***Change objective***
Is motivated to interact with robot ongoingly	Autonomy, relatedness and competence (self-determination theory)	Experiences increased autonomy, relatedness and competence while interacting with the robot
Develops a relationship with the robot	Reciprocal disclosure (social penetration theory)	Feels confortable to self-disclose personal information to robot

To engage on determinants and achieve the change objectives, for both interaction and intervention, relevant behaviour change techniques (BCTs) are inventoried from theory (e.g., behavioural, cognitive, and psychological) and mapped on the change objectives. Michie and colleagues developed a taxonomy of hierarchically-clustered techniques, which have proven their effectiveness and can be applied in the development of evidence-based behavior change interventions [27]. In addition, a golden standard to report BCTs was provided [28], which is applied in the current article regarding persuasion at the macro level. Subsequently, the practical application of these techniques, per change objective, is described in terms of strategy. Tables III and IV provide examples of strategies based on BCTs mapped on change objectives of the intervention and interaction.

TABLE III. MAPPING TECHNIQUES ON CHANGE OBJECTIVES AND DESCRIPTION OF STRATEGY OF INTERVENTION

Change objective	***Behaviour change technique (theory)***	***Strategy***
Expresses the ability to cope with unusual situations	Self-monitoring of behaviour (self-regulation)	The child keeps a diary online of its daily activities, self-management activities (e.g., food intake), diabetes parameters (e.g., blood glucose level)
Automatically applies coping behaviour when faced with unusual situation without explicit decision making	Habit formation (behavirorism)	The child is presented with an otherwise uncommon situation and repeatedly practices coping behaviour for that situation

TABLE IV. MAPPING TECHNIQUES ON CHANGE OBJECTIVES AND DESCRIPTION OF STRATEGY OF INTERACTION

Change objective	***Change technique (theory)***	***Strategy***
Feels he/she can decide for him/herself the length of the interaction with the robot (autonomy)	Flexibility of task (learning theory)	The robot asks the child if it wants to contine playing current activity (quiz) or maybe switch to another activity (sorting game)
Feels that by interacting longer he/she becomes	Offering challenge (zone of proximal	Playing a quiz about diabetes is likely to enhance the child's feelings of competence, not

Change objective	Change technique (theory)	Strategy
more competent in interacting with the robot (competence)	development)	only because of the challenging nature of the quiz, but also as a result of the comments and positive feedback from the personal robot.
Feels comfortable to self-disclose personal information	Demonstration of the behavior (social penetration theory)	Robot discloses personal information to the child as to persuade the child to do the same

A formal contextualization of the intervention and interaction with the system is provided through scenarios. A scenario is a description containing actors, background information on the actors and assumptions about their context, goals or objectives, and sequences of actions and events [29]. Design scenarios, which provide short storyline of how an actor or persona will be using the system with few details (Fig. 2). Due to these characteristics, design scenarios greatly appeal to experts from different fields and can be easily used to draw a communal picture of how the technology should work to achieve the specified objectives.

John (age 9) has diabetes type 1 and plays various activities with the personal robot, such as playing a quiz and a sorting game, keeping a diary, and doing a dance. These activities contribute to the developing health literacy, skills and self-efficacy relevant for his diabetes management. Also, the robot interaction style contributes to the child's feeling of autonomy, development of competencies.

Fig. 2. Design scenario

From these design scenarios more generic use cases can be derived (Fig. 3). They provide a sequence of interactions between multiple roles or actors. A use case is situated, i.e., related to a given circumstance, context and/or activity. Use cases are defined according a predetermined format, containing:

- The goal of the interaction and intervention (at the macro and/or micro level);
- The actors which are involved in the use case, both human and technical;
- Pre- and post-condition of the interaction. These are descriptions of the prerequisite initial state to commence the use case and the target end state when the use case is fulfilled (i.e., all actions are performed by user and system);
- A sequence of actions which the user and the system perform, collaboratively;
- A reference to the requirements, which can be elicited from the use case.

Scenarios play an important role in envisioning the set of requirements and claims [30]

Requirements are functionalities the system needs to be able to perform, address or satisfy. They describe what the system should do, covering concrete observable actions, elected from scenarios and use cases of the system and results. Descriptions are in terms of the strategy, system's function, hardware (technical) and software (interface). Strategic requirements contribute to the intervention (high level persuasion). This is a new concept for system engineers, which is essential to come to long-term behaviour change. Functional, hardware and software requirements contribute to interaction (i.e., low level persuasion). Requirements can be phrased, as follows:

- Strategy: 'The robot shall provide instructions and demonstrations, and stimulates practice through rewards and feedback, to contribute to self-management skills building.
- Functional: 'The personal robot shall have a personality, which it can talk about when asked, to attend to the child's need for relatedness'
- Technical: 'The personal robot shall make use of Wi-Fi connection to interact with the user model, with a minimum connection rate of 150Mb/sec'
- Software: 'The personal robot shall play a quiz with the user through a java build quiz interface.'

Goal

- Intervention: Increase diabetes health literacy and ability to explain how to perform glucose self-monitoring
- Interaction: Increased sense of competence while interacting with the robot

Actors

John, robot

Pre Conditions

1. The robot and John are in the hospital. John has some knowledge on his illness

Post Conditions

1. John increased his diabetes health literacy

Action Sequences

1. Robot asks John if he wants to play a quiz on diabetes
2. John agrees
3. Robot explains the multiple choice style quiz and ask if John understand the quiz
4. John states he understands de quiz
5. Robot poses the first question and gives four answer possibilities
6. John picks answer B
7. The robot explains that answer B is incorrect and asks John to give it another try
8. John picks answer C
9. The robot congratulates John on giving the correct answer
10. The robot compliments John on his performance
11. It is John's turn to ask the robot a question
12. Etc.

Requirements

- Req1. Robot shall provide recognize correct and incorrect answers of the user and provide educational feedback
- Req3. The robot shall take and give turns, to facilitate learning by example

Fig. 3. Use case

C. Evaluation

The development decisions made until now, although informed by expertise and theory and evidence from research, still may not be optimal or may even be incorrect. Through evaluation, developers can determine whether decisions were correct at each development step. The logic model, originating from intervention mapping, has a key function in the proposed approach in regard to evaluating persuasive technology. Logic models describe intervention resources, activities, outputs, audiences, and short-, intermediate-, and long-term outcomes related to a specific problem and situation [31]. Principally, it back-tracks through the specification, whereby critical measures of performance are identified and measured, and claims are validated.

At the onset of the evaluation, claims are stated about the hypothetical outcomes, when requirements are fulfilled in relation to change objectives for intervention and interaction (Fig. 4 and 5). Claims justify why certain requirements are needed by describing the expected effects, which is set within certain contexts (i.e., use cases). Claims state the expected effect and point out the trade-offs between the advantages and disadvantages of the related requirements.

Effect

Child learns about what is diabetes type I

Positive outcome

+ Child knows about diabetes type I and how to manage it, in theory

Negative outcome

- Child does not learn about how to cope with uncommon situations, caused by the illness

Fig. 4. Claim about intervention (macro level persuasion)

Effect

Child appreciates playing different educational activities with robot

Positive outcome

+ Child is motivated to play with robot during multiple weeks

+ Child keeps on playing and increases knowledge about diabetes

Negative outcome

- Child is used to repeatedly playing new activities and becomes disappointed/frustrated when the system runs out of new activities

Fig. 5. Claim about interaction (micro level persuasion)

Claims are validated through evaluation, at the level of the interaction, through process evaluation, and the intervention, through effect and impact evaluation. Process evaluation is designed to answer the question of whether the interaction is feasible and usable, if the technology is representable and what is the anticipated effectiveness, when fully developed. User experiences with the technology are assessed and results are used to iterate the specification at the micro persuasion level. Validation takes place through simulation, prototyping and human-in-the-loop-testing. Also, the claims can be reviewed with experts and end-users through interviews, focus groups and surveys, possibly based on mock-ups and/or paper prototypes.

The effect evaluation is designed to answer the question of whether the intervention is working or not. Results can be used to iterate specifications of the intervention and provide guidance when deciding about scaling up. During the effect and impact evaluation, validation takes through trials, such as a randomized controlled trial or a quasi-experimental design. In these trials, the change in health and quality of life problems, change objectives at the macro persuasion level, and determinants are observed and analysed.

III. Discussion

Developing persuasive technology requires an approach, which covers technological features and behaviour change strategies. Addressing both aspects contributes to its usability, reproducibility and effectiveness. The approach presented in this paper, fulfils this prerequisite by integrating sCE and IM frameworks. Applying this multidisciplinary approach generates building blocks from theory from different fields, including health psychology and human factors. Also, it specifies objectives and requirements, described in the context of use, for both intervention and interaction, thus covering both high and low level persuasion. Finally, it evaluates process, effect and impact, whereby claims on interaction and intervention are validated. As a result, it aggregates and reuses knowledge of evidence-based interventions and addresses characteristics of the users and their tasks and roles within their daily performance situation, leading to both effective and usable persuasive technology. Moreover, it avoids 'black box' effect and impact evaluations, which give a finding on impact, but no indication as to why the intervention is or is not doing what it supposed to do [32].

Developers involved in the development of persuasive technology come from different fields and often speak different a jargon, matching their perspective on development and expertise. This can lead to misunderstandings, at the cost of the integration of the different frameworks and success of the proposed approach. Therefore, the approach is presented as a guideline, accompanied by a glossary, which defines, explicates and illustrates the different components. As such, it offers a *lingua franca*, which, when systematically applied, can improve the communication and collaboration between the different experts involved. Moreover, terms in the glossary are currently further identified and defined to generate a concept map and ontology for reuse in future development projects.

A number of challenges for the proposed approach has surfaced during application (e.g., during the case study). Firstly, methods for continuous involvement of the target population throughout the development process need to be extended and further elaborated. Especially when collecting data on change objectives, strategy, process, effect and impact. To further involve end users, the value sensitive design (VSD) method could be integrated in the approach. This theoretically grounded approach addresses design issues within the fields of information systems design and human-computer interaction by emphasizing the ethical values of direct and indirect stakeholders [33]. Second, effectiveness of BCTs are constrained by boundary conditions, i.e., variables beyond which the experiment effect will not generalize [34]. Illustratively, techniques applied in persuasive technology designed to motivate people with chronic pain (CP) to perform physical activity, may be less effective for people with other conditions, as the emotional states in persons with CP play an moderating role [35]. These conditions need to be explored and considered when deciding on the proper technique, within the specification component. Third, business and health ecosystems need to be addressed. These ecosystems strongly affect adoption and implementation of persuasive technology. The healthcare ecosystem consists of the different stakeholders involved in the health promotion of the target population, such as family members, caregivers or employees. For example, a child with diabetes may be knowledgeable on how to prick insulin, but the parent is responsible for making the insulin available to the child. Solely targeting persuasive technology on the child to be medical adherent may be insufficient, and when applying the approach, the social environment needs to be considered part of the user group, with its own specifications (change objectives, determinants, and so on). The business ecosystem includes suppliers, lead producers, competitors, and other stakeholders involved in supplying persuasive technology. To prevent persuasive technology to land on the shelf it is important to specify the infrastructure, offering (i.e., benefits), consumers, and finances (i.e., costs), at an early stage (i.e., low TRL). To further address the healthcare ecosystem, additional steps from IM could be integrated, namely, those under making an adoption and implementation plan [15]. To address the business ecosystem, a business model, with persuasive technology embedded, could be integrated in the approach, focusing on innovation and technology in the healthcare sector [36].

IV. Conclusions

This paper presents a multidisciplinary approach for developing persuasive technology, by combining frameworks from the fields of behavioural and social sciences, psychology, cognitive engineering, and HCI. This approach covers both technological features and behaviour change strategies and offers practical guidance for developing effective, reproducible and usable persuasive technology. Also, it can aid bridging the existing language barriers between the different fields involved in the development process. The expectation is that this approach will contribute to a sound design rationale, broadening the reach and ongoing use of the technology, and generating larger results in regard to health promotion.

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APPENDIX: GLOSSARY FOR DEVLEOPING PERSUASIVE TECHNOLOGY

Concept	Definition
Actor	An actor is either a stakeholder or an (syntehtic) agent, able to perform actions within the system
At-risk population	Population, whose members may have additional needs before, during, and after an incident in functional areas, such as medical care. They form the target gorup of the intervention
Change objective	The change the actor believe will best address the health behaviour and interaction challenge(s) identified
Change objective matrix	Matrix with change objectives derived from performance objectives and important and changeable determinants of behaviour
Claim	A claim refers to an intended and/or side effect of using a particular functionality of the system (described in a functional requirement)
Design rationale	Arguments and reasons behind decisions made when designing a system, such as persuasive technology
Design scenario	A design scenario is a short storyline of how an actor or persona will be using the system. It is linked to a problem description, since the design scenario show in what way the system is intended to solve the described problem
Determinant	Factors that have been found associated with the performance of the behavior of the target population or agents that have control or influence over environmental outcomes
Evaluation – process	Evaluation designed to answer the question of whether the interaction is feasible and usable, if the technology is representable and what is the anticipated effectiveness, when fully developed
Evaluation – effect/impact	Evaluation designed to answer the question of whether the intervention is working or not
Human factors	Theory, principles, data and methods to design in order to optimize human well-being and overall system performance
Levels of persuasion	Macro level persuasion has an overall persuasive intent, regarding behaviour change. Micro level persuasion, or *microsuasion*, aims at persuading the user to continue interaction with the technology
Measure	The dimensions, quantity, or capacity of something as ascertained by measurement with a validated instrument
Need assessment	The discrepancy between current well-being, quality of life and health conditions and desired conditions, for the at-risk population
Operational demands	Work and/or activity conditions for the actors interacting with persuasive technology
Requirement	Some functionality/capability the system needs to be able to perform/address/satisfy. It is a singular documented function that a particular design, product or process must be able to perform
State-of-the-art (SOTA)	Current highest level of general development, as of a device, technique, or scientific field achieved
Strategy	Description of practical application of a BCT to engage on a determinant and achieve a change objective
Use case	A sequence of interactions between multiple roles or actors. A use case is situated, i.e. related to a given circumstance/context/activity