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Reflective Healthcare Systems: micro-Cycle of Self-Reflection to empower users

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Abstract. Data collection and reflection are considered an integrated process in Personal Informatics to help users take action towards changing behaviour. Facilitating the collection and visualization of large data sets has been a major technical challenge to guarantee meaningful and effortless information to users. However this focus results in a passive involvement of users in these stages, creating distance between the user and their data, thus hindering proper understanding of people's current behaviours. Designing for active participation may aid users in forming a closer bond to data. Going beyond the support of visualization of performance data, this paper introduces ESTHER 1.3 as an approach to facilitate active mini cycles of self-reflection (mCR) by means of in-situ self-reporting mechanisms. ESTHER 1.3 is presented as an implementation of this mini cycles in the context of physical activity and knowledge workers. A field study evaluation of 23 days with 5 users shows the opportunities of the mini cycles to engage people in deeper reflection and to support them to perform better-informed actions, as well as the challenges in the implementation of mCR elements for a specific context.

Keywords: Empowerment, self-reflection, self-reporting, personal informatics systems.

1 Introduction

Digital technologies could revolutionize the healthcare system by encouraging the patients to be in charge of their own health [1]. Designing for user empowerment provides users with the necessary information to self-reflect and gain control of their own situation making conscious and insightful decisions [2]. Designing for empowerment involves engaging users in an iterative process of four steps [3]. The first step involves gaining knowledge. This requires having access to information, resources and a range of options that are self-determined by people to be able to take proper informed decisions [4]. The second step is awareness, supporting the moment when people are able to ground themselves in the present by understanding the elements that run their lives. The third step is self-reflection that supports the thinking and analysing process of one's behaviours in meaningful moments over a long period of time [5]. The final step is action; a self-empowered person is an expert about their own life able to point to clear directions to act upon. Therefore, taking a user empowerment approach in the design of healthcare technology, proposes to set challenges beyond the efficiency of a system, towards providing deeper and meaningful experiences by engaging users actively in the process of understanding their current behaviours and exploring the possible new behaviours.

Personal Informatics (PI) is an emerging area in the field of Human-Computer Interaction that focuses on collecting personal relevant information, with the goal of supporting people to reflect on existing behaviours and take action towards changes in behaviour. PI implements five consecutive steps to support behavioural change: preparation (what data will be collected), collection (how data will be collected), integration (how data will be processed and presented), reflection (what strategies to develop) and action (implementation of strategy) [6]. Self-reflection is considered a key element in the design of PI systems [7], however most of the developments to date have been focused on designing technologies for the optimization of data collection and integration. The involvement of automated sensors and advances in data analysis and visualizations may contribute to the selection of what is relevant to show and links between the data. However, individuals' interests, cognitive capabilities and emotional states play also a key determining which information is relevant and should be integrated with sensor data.

The work presented here explores the use of self-report techniques to empower users in the Integration phase of PI. Light and short instances of self-reports could be used as experience-based tags [8] to label a certain piece of objective data captured by sensors, which are then timely visualized. Therefore, self-reporting techniques could transform the collection phase into a dynamic construct, which involves Integration. This may increase the ability for users to reflect on their behaviour. An increase in reflection may provide individuals with valuable personal insights, and thus increasing their motivation to self-report on a frequent basis.

In this paper, ESTHER 1.3 (Experience Sampling for Total Hip Replacement), a personal informatics mobile application that implements the notion of self-reporting, is presented in the context of an application for monitoring and providing feedback on knowledge workers' physical activity levels. As office workers tends to be sedentary and physical activity is not a priority in their busy agendas, they are often unaware of the need for physical activity at work. Implementing new (healthier) practices is generally seen as a high threshold without visible outcomes. Top down initiatives seems inadequate to address every worker's need while lack of awareness and support hinder bottom up enterprises. The ESTHER 1.3 mobile application was designed to help knowledge workers integrate physical activities into their schedules without affecting their work routines. The study involving ESTHER 1.3 aims to contribute to the design of PI technologies by extending "integration" as an active trigger to stimulate reflection. In the following sections the design context and related work, as well as the deployment challenges and evaluation of ESTHER 1.3 are discussed in relation to empowering the user.

2 Knowledge workers and physical activity at work

Knowledge workers are mainly professionals whose job is to interpret and transform information [9] consequently spend most of their working time engaged behind a desk. Their wellbeing at work has gained attention, as the stress and sedentary work associated with office work leads to unhealthy work practices characterized by insufficient physical activity, which raises the risk of numerous diseases [10]. Office work is characterized by switching from one task to another, leading to fragmented chunks of work with a sense of urgency to finish tasks while engrossed in work periods often lasting three hours [11]. Given such work routines which may become habits, knowledge workers put their health at risk. Although there is a substantial body of literature confirming the need for at least 30 minutes of physical activity at work and hourly breaks of five minutes, the level of sedentary behaviour is increasing [12]. In an effort to promote physical activity at work, most initiatives refer to company policies and campaigns to reduce sedentary behaviour by promoting regular work breaks as opportunities to perform some physical activity [13, 14]. However, these initiatives do not directly involve the worker in adopting physical activity in their busy and hectic agendas.

A proactive strategy towards increasing physical activity for office workers can be found in commercial applications and related research projects. Assistive technologies are offered as a means to persuade people to become more active. For example, Office Exercise (accessed by http://play.google.com) prompts users to perform certain exercises so as to change posture after a prolonged period; the research project WalkMinder [15] offers a glanceable display and mobile phone vibrations to interrupt extended periods of inactivity; and the research project MoveLamp [16] is an ambient light display that serves as a reminder to move, and provides feedback on physical activity levels during work. The assistive approach of these systems focuses on providing instructions rather than increasing awareness and reflection. As highlighted by [17] there are a limited number of studies that focus on the process of reflection in designing personal informatics systems.

3 Micro-cycles of self-reflection

Pirzadeh et al. [17] define reflection as a process in which one thinks and explores an issue of concern to make it meaningful for oneself, leading to the development of a new conceptual perspective. Reflection mechanism increases awareness [18] and can motivate users of Personal Informatics systems to gain an understanding of the relationships between different sources of data [19]. As noted above, the stage model of Li et al. [6] captures five phases for the design of Personal Informatics: preparation, collection, integration, reflection and action. While technology alone may be a means to serve the first three PI phases, the user should be the primary actor who is involved in the last two phases. This logic division of using technology to minimize human effort in managing data, becomes a barrier for users to make sense and use of the information presented.

The micro-cycles of Self-Reflection (mCR), based on the principle of user empowerment, extend the integration stage of PI with interaction design elements to implement light but engaging user involvement with data. mCR explores interaction properties in the implementation of self-reporting techniques to ensure active participation with minimal effort. The properties of mCR are:

- *energetic*: opens a moment of reaction; provokes reaction
- *high frequent*: able to capture nuances and fluctuations
- *linked:* prompts are triggered and linked to relevant situations, context, etc.
- *light:* minimal cognitive effort to report
- *short:* minimal time effort to report

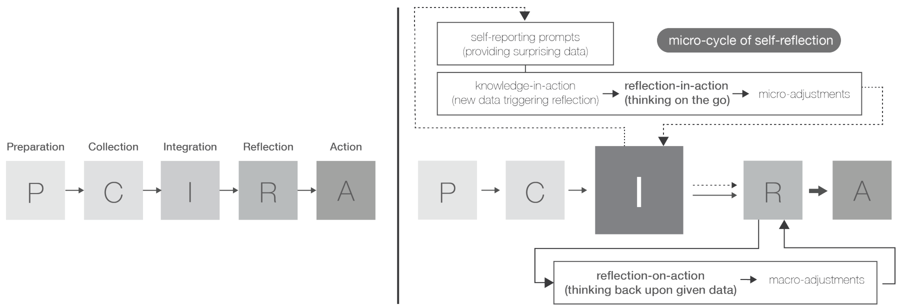

Fig. 1. Traditional "staged-model (left) and "active integration staged-model (right) of Personal informatics

The mCR can be compared to Fogg's term *microsuasion* [20] in the design of persuasive systems. Microsuasion incorporates light interaction elements to influence user in achieving sub-goals. Examples of microsuasion elements are reminders, pokes, notifications or nudging pop-ups windows. An example of mCR, is self-reporting. The challenge to implement micro-cycles is that while microsuasion elements are triggered by the system, micro-cycle is a user's responsibility.

3.1 Components of micro-cycles of self-reflection

At the root of the concept of mCR is the process of Reflective Practice [20] that describes how people analyse experiences in order to learn from them. Reflective Practice is a process between reflection-in-action and reflection-on-action and happens when thinking and acting are combined. Reflection-in-action helps people in the activities of completing a task, by supporting people to reshape their activities, while they are working on them. Reflection-on-action is a final reflection, thinking back in order to understand why things did not work out as expected [21, p. 26]. The full process of Reflective Practice requires three other linking elements:

- *Knowing in action:* tacit knowledge and feelings implicit in one's actions.
- *Surprise result*: unexpected results to be made sense of and further exploited.
- *Knowledge in action:* when the surprising information triggers reflection.
- *Reflection in action:* thinking what is happening without stopping the action.
- *Reflection on action*: framing the problem to reshape the current strategy.

These linking elements constitute a mental process and they have been integrated into mCR to support reflection-in-action. The properties of a micro-cycle may trigger knowledge-in-action by prompting mechanisms. The action of self-reporting could bring new thinking upon surprising data that leads to reflection-in-action, making the integration a more active stage. The implementation of a Reflective Practice process within the Personal Informatics staged-model is described in Fig. 1.

In the following sections, ESTHER 1.3 is presented as a situated design intervention implementing micro-cycles of self-reflection in the context of knowledge workers and physical activity during working hours.

Fig. 2. Interaction design elements of ESTHER 1.3

4 ESTHER 1.3

ESTHER 1.3 illustrates an implementation of mCR in the context of physical activity by means of in-situ self-reporting mechanisms. A functional prototype was developed for the Android platform to be tested in the field. In the development of the prototype previous knowledge and experience regarding the design of personal informatics systems are considered. The details of the design of ESTHER 1.3 have been published elsewhere [22].

4.1 Design elements

ESTHER 1.3 features two types of interaction elements: active elements that require explicit user actions and assistive elements that provide relevant and timing information to user. Active elements are implemented by means of in-situ prompting mechanisms of self-reporting (mCR) and goal setting. Assistive elements provide physical activity monitoring, visualizations, and notifications.

Physical activity monitoring. Physical activity is monitored using the in-built accelerometer in smartphones and an algorithm that processes movements into number of steps. Real time physical performance is visualized by colour coded rays emerging from the centre of the main ring (inner space, Fig.2, group 3). Four levels are represented by 4 different shades of green: white=no activity; light green=low, 20 steps/min.; mid=medium, 60 steps/ min.; and saturated green=high, 100 steps/ min.

Scheduling targets of physical activity. Everyday the system asks the user to schedule at least 4 targets of 5 minutes walking through out the day, which is displayed in the outer (blue) ring of the interface (Fig. 2, group 2). Each target of 5 minutes represents 500 steps as the minimum threshold. The ring circle is divided in 4 segments of 2 and 3 hours to help users distribute their goals accordingly to specified health standards. Targets are displayed by default in a green colour; they change to yellow or red depending upon whether the minimum threshold of 500 steps was not achieved (red), just achieved (yellow) or far achieved (green). Visual notifications including vibration and sound are provided 5 minutes before a set target is approaching.

Micro-cycles of self-reflection. ESTHER 1.3 implements mCR by developing two mechanisms: in-situ prompts and self-reports. In-situ prompts use an algorithm that triggers a prompt once in each quarter. Prompts are notified by an on-screen visualization and optionally vibration and sound. The visual notifications use exclamations defined as energetic elements, WOW!, OK!, OOPS!, for green, yellow, red targets respectively, with the aim to surprise and provoke the user to self-report. The self-report offers two options to report on: the emotion towards the prompt and the activities performed when the target was prompted. Users can select one emotion from a list of five: happy, confused, annoyed, great and sad and a maximum of two activities from a list of six: meeting, working, eating, phone, chatting, and other activities. The self-reports are visualized next to the prompted target. Additionally, users can add an extra emotion and activity as well as comments, without the need of a prompt. These extra self-reports are also displayed on the outer ring positioned at the time when the user input the self-report, whereas the comments can be accessed on an in-built notepad. Finally, a history of previous days is also provided.

5. Case study

The goal of the study is to explore an implementation of mCR in the context of physical activity in the working place. The expected outcomes aim to uncover issues related to user experience and personal values that may emerge from the self-reflection practices supported by the proposed mCR implementation. The study is framed following the approach of ‘design in the wild’ [23] where the need for more depth and contextualized knowledge is promoted to properly understand the complexity in designing technologies that aim to have a sustained impact in daily life practices. This requires a pragmatic approach to be able to get into people’s experiences and discover the personal values they could attach when using the proposed interventions in their own context. Thus the intention is not to generalize knowledge but to get deeper insights into people’s experiences.

5.1 Participants and protocol

The study setup involved knowledge workers and two interfaces of the application that were deployed for two weeks each plus an initial baseline study of three days, performed in two working environments. In all three interventions participants were asked to carry the phone in their pants, trousers or skirt pockets. In the baseline condition steps were monitored, without providing an interface to the user; the control condition allowed the user to set targets and being provided with real time visualization of physical activity; the experimental condition included mCR self-reporting. The experimental design was within-subjects.

Six knowledge workers (3 female and 3 male) were invited to participate, two of them volunteers from an ICT company and four from a university in The Netherlands. All participants contributed to the baseline (no-GUI); three of them (B, D, and F) were assigned to start with control condition (without mCR) and three (A, C, E) with experimental condition (with mCR) for the first 10 working days and then alternate to cancel out order effects. During the study, participant F was unable to be actively involved; therefore he was excluded from the analysis. Participants' average age was 34.6 (SD=11.7). The three stages of the study were spread over four weeks. The study protocol was conducted by a research assistant who was first trained to do so.

During the introductory interview, ESTHER 1.3 was downloaded on the participants' smartphones from Play Store. The research assistant ran the application for the first time to enter demographic information and to setup the initial condition. Participants were asked to carry their phones in their pocket following their normal daily office routines. For the control and experimental conditions participants were also asked to interact with the app. A brief demonstration and short training on how to use the application was given. After each condition the assistant researcher visited each participant to download the locally stored data and to change the application setting to activate the new condition.

5.2 Data collection

Both quantitative and qualitative data linked with a time stamp were collected for the analysis: a) system generated data of physical activity in form of number of steps every five minutes, prompts and notifications; and b) users' inputs: setting targets, emotion reports, reported activities, and text comments. Additionally, the system stored a screenshot of the main display at the end of the day. Data was stored locally in a text file and collected after each condition was completed.

The Flemish Physical Activity Computerized Questionnaire (FPACQ) [24] was administrated to the participants at the beginning of the study and after each condition was completed to provide a reference of the perceived level of physical activity.

The study ends with a semi-structured interview to discuss participants' experiences and the perceived value of the application. In order to guide these discussions, the daily snapshots and the results of the FPACQ were used as probes, to address relations between the actual behaviour and the elements provided by the application. The interviews were transcribed and translated from Dutch to English.

5.3 Results

Excluding the study days affected by technical difficulties with the application, Christmas holidays, absent days and participants forgetting to bring their phone to work, a total of 99 days reported from all participants were included in the results and analysis. Per day, 10 hours of data plus one screenshot were collected from each participant.

Table 1. Total number of user inputs: goals set, self-reporting (emotions, activities, comments) and the number of responded and no-responded prompts per participant.

		A	B	C	D	E	AVERAGE
Targets set		40	42	29	31	40	36.4
Moods total		28	28	1	9	32	19.6
Activities		28	31	1	2	32	18.8
Comments		16	2	0	0	0	3.6
Prompts	**Responded**	17	18	0	7	20	12.6
	No responded	23	24	28	24	20	23.8
TOTAL		**112**	**103**	**31**	**42**	**104**	

Table 2. Performance of physically active participants

Targets	Participant A		Participant C		Participant D	
	Control	**Experim**	**Control**	**Experim**	**Control**	**Experim**
Set	40	40	29[1]	29[1]	40	31[2]
Achieved	15	23	7	13	0	5
Partly achieved	12	6	6	4	3	5
Not achieved	13	11	16	12	37	21
Improved performance*		5%		14%		25%

[1] issues with smartphone battery could explain the low commitment; [2] considering only the first 6 days;
* improved performance is calculated on the basis of the achieved and partly achieved targets

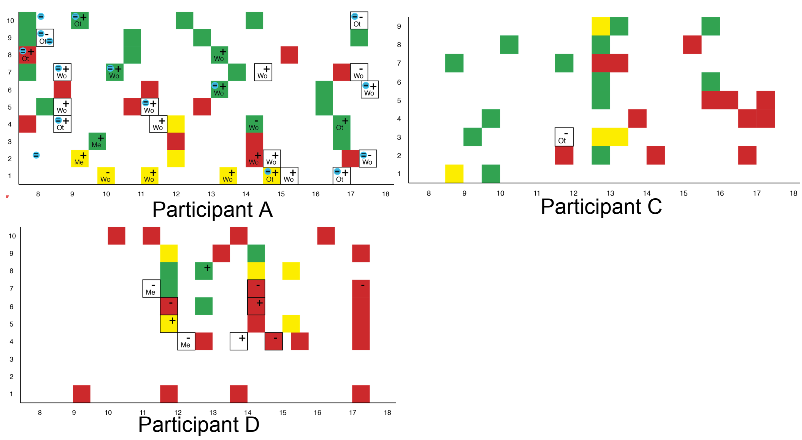

Fig. 3. Performance of physically active participants in the experimental condition

Table 3. Performance of non-physically active participants

Targets	Participant B		Participant E	
	Control	Experim	Control	Experim
Set	25[1]	42	40	40
Achieved	3	10	5	10
Partly achieved	4	8	17	16
Not achieved	18	24	18	14
Improved performance*		11%[2]		10%

[1] participant forgot to use the application; [2] considering only the first 6 days
* improved performance is calculated on the basis of the achieved and partly achieved targets

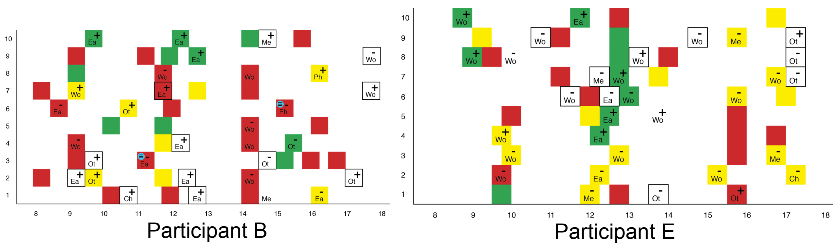

Fig. 4. Performance of non-physically active participants in the experimental condition

Table 1 provides an overview of users' input. All participants set daily targets during the 10 days of the control condition (without mCR) and experimental (with mCR) conditions. The number of targets set per day was, on average 3.82 (SD=0.52) and 3.64 (SD=0.59) in the control and experimental conditions respectively. With a recommended amount of four targets per day, this result demonstrates that there was an active degree of involvement of users in setting goals.

Based on the results of the FPACQ two profiles were defined: physically active participants (A, C, D) and non-physically active participants (B, E). Physically active participants were described as doing more than 3 hours of moderated and light off-work physical activities, and having a brisk walking pace. Non-physically active participants were described as performing less than 1-3 hours a week of moderate activity at work and having an average pace walking behaviour.

The performance of these two groups is presented in Table 2 for physically active and Table 3 for non-physically active. The improved performance presented, is calculated on the basis of the achieved and partly achieved targets.

Similarly Fig. 3 and Fig. 4 visualize the performance in the experimental condition for physically active and non-physically active respectively. The horizontal axis represents working hours (8am and 6pm). The vertical axis shows the number of days of the trial, increasing from bottom to top. The red boxes represent not achieved targets where insufficient level of activity is detected in the time period set for the target. Yellow boxes represent partly achieved targets based on two criteria: below the standard level of activity is detected during the target period; or a significant level of activity is detected in the time vicinity of the target and that is not related to another set target. The green boxes represent achieved targets where sufficient level of activity is detected in the time period set for the target. The labelled boxes represent participant's activity reports (Wo=work; Ot=other; Me=meeting; Ea=eating;

Ph=phone; Ch=chatting) and emotion reports (+=positive; − =negative). The white boxes represent reports not related to a prompt.

6. Analysis and findings

In the analysis here the development of goal setting strategies for the two conditions tested and for the resulting two user profiles identified are described. Secondly, the elements of the application that supported the observed strategies and resulting performance over time are discussed. The analysis is based on the two observed user profiles of physical activity to explain high and low involvement with the application.

6.1 Physically Active Participants

Participant A (male), being a researcher on persuasive technologies, had an intrinsic interest in the research as well as on validating self-knowledge of his daily physical activity habits at work. This led to the participant being critical of the application, often questioning the accuracy of the application and always aiming to improve his performace in achieving targets. Participant C (female) was particularly interested in how the system could help her in planning targets for her highly diverse working schedule, which made it hard to plan targets ahead. Participant D (female) was characterized by not following a strict agenda at work. She initially showed less interest in setting and complying to targets at specific times. Instead, she was motivated to learn as to when she was physically active at work.

With the exception of participant A, physically active participants displayed a relatively low degree of involvement in providing inputs to the system (see Table 1). The low level of engagement relates to the low value all three participants reported on how the tool assisted them in their needs. Though participant A was highly involved with the application his general perception towards the app was that it did not support him in finding new strategies to improve his physical activity at work: *"I realized (sometimes) it would help me to move more, but it didn't help me in finding new ways to do that"[Participant A].* Similarly, participant D reported that the system was useful to check personal progress, but she was not interested in developing strategies to set targets and change or modify physical activity habits: *"I know that I missed several targets every day, but that doesn't really matter for me"; "… I want to walk. And I don't really care about the targets" "… there was no real intention of the time. I know somebody would probably check their schedules to check when they could have a walk or whatever. But I don't" (participant D).* Likewise, Participant C did not find the application useful in improving her current level of physical activity.

In particular the **prompts and self-reports** were perceived as having little value to support reflection and development of new strategies to become more active. For Participant A, the intended interaction of reporting feelings in reaction to the prompts was misunderstood, thus considering the options provided by the system as inappropriate in the work context. Participant D used the reports to indicate to the system that a prompt was not well timed; she did not consider the information to be useful in reflecting on her strategy to set targets since met or unmet targets triggered the prompts. This reflects a mismatch in what Participant D expected from the system and what the system intended to offer. Participant C did not pay much attention to the self-reports. Interestingly, Participant A was the only one that frequently used the comments to explain why he did or did not reach a target, and considered them valuable to later reflect on what happened.

Despite the low overall value attributed to the system, this group reported some of the mCR elements as been beneficial to improve performance. The benefits reported by this group related primarily to improving knowledge on their performance, and to be motivated to increase performance.

Regarding knowledge, the **inner space** and **step counter** were reported as useful features to learn from one's performance during the day: "*... I think the green stripes, and how big they are in a day had more that function for me, so I could see how it differs. And setting the targets maybe was more valuable than the prompting for me"[Participant C].* Participant A and D reported using the **history** to learn from previous performance.

Regarding motivation, the **notifications of upcoming targets** and **step counter** were reported as being strong motivators to reach the daily steps recommended, which may explain the improvement in performance during the experimental condition (see Table 2) of all three participants. Participant C reported on the value of the **notifications to set daily targets** to remind him to adjust new strategies every day: *"My days are so different, and I have very different kind of activities. And I tried to fill it in accordingly to appointments, so if I have a meeting or something, then I place it before or after. But to have this moment of planning in the morning where you think about it is really nice I think, it motivates me"[Participant C]*

6.2 Non-physically active participants

Participant B (female) had little knowledge of her own physical activity behavior and no experience with physical activity tracker applications. Therefore she was initially motivated to know how she actually performed during working time. The hectic work agenda of this participant challenged her initial engagement with the system (in fact she often forgot to use it in the first condition). Participant E (male) described his work as routinary and sendentary. This was a motivation for him to use the application and learn about his physical behavior.

Both participants showed a relatively high engagement with the system (see Table 1) and a clear improvement in performance in the experiment condition (see Fig. 4).

The main difference with the physically active participants is that the non-active group attributed their improvement to the system. Both participants perceived the system as a valuable tool to understand daily habits in physical activity, reflect on current behaviours, develop strategies for setting realistic goals and be motivated to achieve them: "*It made me think [the application] that I do very little activity during the day and it left me curious to track my physical activity myself. I did change my behaviour" [Participant B]*

Both participants reported that **prompts and self-reports** helped them to reflect on ones progress and develop strategies to reach a target: *"The prompting helped me* *prepare mentally to find how to do some activity. In terms of the prompts help me think of the overall, I realized 'Oh I didn't walk that much, so maybe I will take a quick walk". So to change that I would go to the bathroom in the other department or something like that"[Participant B].* Similarly, for Participant E it was perceived as a valuable element to achieve a target since it asks to look at the application and then think about ones progress: *"Here I didn't feel very well probably, it could be that I was a little sick… Then lunch, and I thought I do two targets after it. But well then I often missed those, so I thought well then I do two around lunch, then I may only miss that one in the afternoon" [Participant E].*

Similarly **history** helped to assess previous performance and plan new targets based on such assessment.

Regarding motivators and reminders **notifications of upcoming targets** were perceived as effective reminder by adding certain pressure to take action towards a coming target. For Participant B, the **outer ring** was perceived as an effective source of motivation by visualizing the set targets and the ones already achieved.

7. Discussion

The design of healthcare technologies implies designing for a sensible human condition in the complexity of the daily life practices of an individual. Prototyped technologies and interaction designs provide a means to experiment envisioned interactions in real settings [23]. ESTHER 1.3 served as a prototype to evaluate the acceptance of self-reporting as an interaction element that can be adopted and adapted into existing daily practices in a healthcare situation. As stated by Rogers [23], the value of prototyping in the wild is associated with revealing deeper insights contextualized in the complexity of daily life practices different to what can be captured in lab studies. The advantages of these 'wild studies' are however challenged by the traditional position in HCI that assesses studies on the number of participants, instead of the ecological validity of the studies conducted. The latter involves high cost and tenure: monitoring what people do, what they experience and feel and most important how behaviour and experience change over time.

The evaluation of ESTHER 1.3 presented in this paper, aims to provide contextualized knowledge that uncovers interdependences between design, technology, experiences and behaviours to further explore implementations that support people to develop their own changing strategies with the help of self-reflection and self-reporting. The implications to healthcare are proposed in areas where 'bringing patients in charge of their own situation' [25] could resolve existing problems such as early release in hospitals (e.g. after a hip replacement surgery) or home treatment for chronic diseases (e.g. COPD). Earlier work has confirmed the opportunities of self-reporting in the context of home recovery [26]. However, the challenge to further explore design implementations in this highly sensible setting, led to the decision to choose the context of a knowledge worker, being relatively more accessible while raising similar or even greater challenges concerning the adaption and adoption of monitoring and self-reporting interventions into daily life practices.

Future work aims to focus on the home recovery context for outpatients and validate the lessons learned in this study.

The goal of this study was to explore an implementation of self-report prompting as a mCR mechanism applied in a specific context. The discussion presented below reflects on this implementation and the value of mCR to empowering through reflection. The discussion is structured based on the empowerment process addressing *awareness*, *reflection* and *action* [3].

Despite the small sample size in terms of number of participants, possible trends were observed across the qualitative and quantitative data collected. The most salient result showed that ESTHER 1.3 affected participants' physical activity in three different aspects. First, it influenced the level of awareness when compared between conditions. Second, an improvement in achieving targets was observed across participants between control and experimental conditions and within conditions. Third, the interaction elements developed to support reflection had different effects and values between the physically active participants (A, C, D) and non-physically active participants (B, E).

7.1 Empowerment by Awareness

People with strong habits tend to favour or seek out information that confirms their views, believes and behaviours [27]. In the presented study, active participants had an initial awareness of their activity level, thus their needs relate to assessing their progress and develop strategies to improve or maintain it. In their interaction with ESTHER 1.3, they found the features such as step counter, history and the inner space to be valuable because of the descriptive and informative information provided on their current performance. They preferred assistive features such as notifications, as mechanisms to achieve their goals, in checking and assessing their performance. The self-report prompts were perceived as less valuable; the active role suggested by this feature was probably not suitable, as the active participants knew what strategies to implement, instead they primarily needed support to put them in action. On the other hand, non-active participants presented a more active engagement with the system, which can be explained by their initial lack of awareness about their situation. They benefit from an active interaction supported by features such as prompts and self-reports to reflect on and assess their strategies and try new ones. They felt empowered to build awareness of their current and past performance, as well as testing out different strategies to improve activity.

7.2 Empowerment by Reflection

The analysis showed preliminary insights that the mCR elements designed to support reflection were perceived with higher value by those who were not physically active, as compared to the active participants. The non-active participants presented a stronger need to gain awareness; therefore they perceived clear benefits in the design elements that supported them in reflecting and assessing different strategies.

As described in the results section, participants presented clear differences in the way they react to the prompts. One way to explain this considers their expectations towards the system. Participant A, been familiar to self-reporting tools and reflection mechanisms, expected a higher level of support in reflecting. He expected the system to support him adding extra layers of information related to his work activities and not limited to physical activity only. Thus he perceived the moods as not suitable, as they were intended to describe feelings towards the quality of the prompts rather than overall feelings at work. On the other hand, Participant D did not perceive value to actively set up (and meet) targets therefore it was not seen as a relevant activity to reflect on; instead she would direct her reports to how good or bad the system was timing the prompts, which was not an implemented feature of the system: the prompts were triggered by the targets set. For her unplanned working style, a supportive system like this was not suitable. She wanted to achieve the goals, but she did not care as to how and when she would do it. This could represent her expectations towards an assistive system that may remind her sporadically about reaching the overall goal.

For the non-active participants (B and E) prompts represented a valuable feature to trigger small reflections on how would they eventually achieve a target and what are the reasons that they have to not do it yet. It can be observed with Participant E that he could explain based on his report how he was feeling at certain moment and how he was thinking to tackle the problem that he was missing already some targets.

Reflecting on the value different participants attached to the mCR properties and the characteristics intended in the initial design there are some points to consider for further development:

- Light: the self-reporting protocol involved simple questions and multiple-choice answers, intended to trigger little moments of reflection with low cognitive effort. As observed, both physically active and non-active participants were triggered by these moments of reflection, but not directly supported by the elements provided by the system. The trade-off between light and limited mechanisms needs further investigation to address different user expectations. Future implementations should investigate the value of adding flexible experience tags in reaction to prompts, as it could provide awareness on momentary experiences that are difficult to recall otherwise.
- High Frequency: The frequency of the prompts was fixed to four times a day in relation to what the health standards require. This short trial provided insights on different values non-active and active participants attributed to the prompts: from triggers of reflection to think about their target strategy to reminders of progress and performance, respectively. This opens the question to investigate the value of personalized prompts where the frequency of prompts could be inversely linked to user's performance.
- Linked: The timing to trigger a prompt was based on the user's physical performance alternating prompts with targets met and not met. It was observed that this link had a positive effect on non-active participants who needed more awareness about strategies and outcomes: targets planned and performance. However not the same was observed with physically active participants which were expecting more layers of information to be linked. This suggests to further investigate the value of adaptive prompts that could be triggered by contextual data such as agenda, indoor climate, and day of the week.

7.3 Empowerment by Action

Different needs for awareness as well as different expectations on what and when to reflect on, described the nuances observed between physically active and non-active participants. These nuances have been described with regards to their level of interaction with the system and the effect on their performance. Both physically active and not active participants found the prescriptive functions such as the notifications and the outer ring to be valuable as assistive and reflective mechanisms to take action towards achieving the next target. Similarly, an increase of targets reached was observed in both groups between the control and experimental condition. However, from the qualitative analysis, differences between the active and non-active participants emerged, possibly explaining different types of interactions that participants expected between them and the system. ESTHER 1.3 implements a supportive system that intends to help people to actively move from stages of knowledge, awareness, and reflection to finally action. This active involvement is expected to support the emergence of practices (actions) that will better fit users' needs and contexts, therefore achieving a long lasting effect. The presented study provides insights revealing different implementations of reflecting mechanisms depending on users' level of knowledge and awareness. One clear difference observed in this study is that active participants wanted to reflect on performance and they required tools to assist their strategies while non-active participants wanted to reflect on their situation as well as the different strategies they would implement to increase their performance. Fig. 3 and Fig. 4 show that not all participants benefit from setting targets and reflecting on the performance. A clear example was Participant D who used almost the same strategy through out the study even though it did not result in a better performance. Although she did wanted to reach her overall goal, setting targets did not match her working style. She would probably benefit more from an assistive system that guides her into creating spontaneous and opportunistic ways to achieve her daily goal.

7.4 Future Work

Being the main objective of this study to demonstrate and analyze the mCR interaction elements in a specific implementation and context of use (ESTHER 1.3 to support physically activity in knowledge workers) the ultimate goal of this study is to inform implementations of mCR in the context of home healthcare. One generalizable outcome of this study identifies the need to understand users initial stage with regards to awareness, reflection and action, as well as their living/working style. From the experience on earlier studies in the context of home recovery [28], identifying the initial stage of a patient could translate to describing patients' clinical background and attitudes towards medical treatment. Regarding living and working style, home activities are less driven by performance than working related activities. Therefore, the implementation of setting targets should be discussed considering other subjective and experiential insights; instead of performance of achieved targets, setting targets could relate to the possibility to distribute patient's physical and emotional energy throughout the day thereby becoming able to do the required and desired activities on certain day. Future work should investigate the transferability of these insights to be applied in the healthcare context.

8 Conclusions

ESTHER 1.3 implemented mCR by designing a reflective mechanism based on self-reporting. It aimed to facilitate critical thinking in knowledge workers about their physical activity during working hours. The implementation offered assistive and supportive interaction design elements allowing knowledge workers to set targets of physical activity, monitor their progress and report on their current activities and emotional states in relation to their targets.

The contribution of the presented study provides insights into how different means of reflection could support different user needs based on their initial awareness of their present health condition. Though the results are not meant to be conclusive the analysis based on the user involvement with the application, gave insights into when supportive and assistive design elements increased experiential value (e.g. motivation and goal-oriented attitude) as well as performance (setting realistic goals and reaching daily targets). As observed, physically active participants valued more the assistive interaction elements to confirm what they know about their physical behaviour and assist performance improvement. In contrast, less physically active participants valued a wider spectrum of interaction elements from assistive to supportive to gain awareness while exploring different strategies. The study provided with design insights for future self-reporting implementations of mCR considering the initial awareness of users. This implication should be investigated in healthcare patients, whom could attribute different value to self-reporting depending on, for example, their initial attitude towards medical treatments.

In summary, this paper presents ESTHER 1.3 as the first design implementation to explore self-reflective mechanisms as an empowerment tool, exploring five interaction design properties to enable self-reporting as a energetic, light, short, high frequent and linked interaction. Self-reporting is presented and discussed as a form of active involvement to support empowerment considering user effort and motivation in the complexity of daily life practices.

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