Design Principles for Digital Occupational Health Systems

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Abstract. Advancements in low-cost and unobtrusive wearable computing devices have prompted employers to begin providing their employees with wearable technology as a part of corporate wellness programs. While the adoption of wearable health-tracking systems might improve employees' wellbeing, the introduction of such systems in organizational settings might also instigate certain tensions, in particular those between privacy and wellbeing, and work and private life. This study was based on an analysis of these tensions; following the design science research paradigm, design principles were derived to minimize such strain.

Keywords: Digital occupational health · Personal health monitoring systems · Design principles · Design science research

1 Introduction

The miniaturization of sensors and electronic circuits has played a key role in advancing low-cost and unobtrusive personal health monitoring systems (PHMS). These systems now feature a wide range of health-related services outside of a clinical setting [1]. Such services emphasize the provision of self-care features to individuals at any stage of the care cycle, enabling the prevention of sickness, early diagnosis of a variety of ailments, and better management of chronic disease [2]. Most of the world's population spends at least one-third of their adult life at work [3]; thus, PHMS have the potential to offer applications that are particularly useful in work environments. To help improve employees' overall health and control the cost of medical care, a growing number of companies have committed to providing wearable devices that offer employees various forms of psychosocial support [4–6]. In this study, the term digital occupational health system (DOHS) is used to refer to digitized health monitoring systems designed for use in work environments and distributed as a means of promoting the health and wellbeing of the greater workforce. The technologies required to enable DOHS goals can be grouped into three main categories: wearable and ambient sensors for collecting physiological, movement, and environmental data; communications hardware and software for relaying data to a remote center; and data analysis techniques for extracting relevant information [7, 8].

DOHS shows considerable promise for extracting meaningful information, providing managers with group performance metrics and employees with self-performance

evaluations, offering health and wellbeing enhancement recommendations, and implementing a greater level of security at work. Yet these systems also raise new challenges. Trust could be the main obstacle for adopting such systems in the workplace. Being monitored by wearable and ambient sensors may result in employees fearing for their privacy. Employers' inability to gain their employees' trust regarding their use intentions could hamper the overall level of acceptance [9, 10]. Thus, systems such as these should provide technical and social means of ensuring that employees' data are safe, and that there is no means of abusing the data produced by the system. Another challenge in introducing and adopting such systems in daily work environments is a possible blurring of the boundary between work and private life, thereby causing social tension. Even though the goal of these systems is to manage and reduce psychosocial risk factors, related social strain could actually provoke stress in the work environment. Work stress can cause employee burnout [11] and diminished organizational commitment and performance [12], so this is a major risk that must be carefully considered.

In response to this novel context, this study argues that researchers should reconsider the social aspects of the design and implementation of these types of systems. This research contributes to the literature on this topic by deriving design principles that will help DOHS gain wider acceptance and lead to a greater level of added value for employees. This work is organized as follows: Sect. 2 presents the methodology, which includes the identification and evaluation of design principles from an information systems design science research perspective. In Sect. 3, the construction of DOHS design principles is presented. In Sect. 4, this study is concluded by outlining the research and practice implications.

2 Methodology

In this study, following the design science research (DSR) approach [13–16] a set of design principles are constructed. The DSR approach is based on a problem-solving paradigm and aims to design purposeful artefacts (i.e., "design principles," "technological rules," and "patterns" "constructs," "methods," "models," "instantiation," and "design theory") [14, 17, 18]. Design principles have been defined as "design decisions and design knowledge that are intended to be manifested or encapsulated in an artefact, method, process or system" [19]. The validation and justification of principles, should be grounded theoretically, internally, and empirically [20]. Theoretical grounding involves the use of external theories and knowledge. Internal grounding is control of internal cohesion and consistency of the design principles. Empirical grounding consists of observations of its utilization and effects.

This study will follow the reference process proposed by Carlsson, Henningsson, Hrastinski and Keller [21] for constructing DOHS design principles:

> *Identifying scope, problem situations and the desired outcomes.* The first step, within the process of deriving the design principles, is structuring the problem at hand to identify a class of goals, which directs the process [22, 23].

Reviewing extant theories and knowledge. Corresponding with the goal of the principles, this activity is concerned with the identification of and refinement of justificatory knowledge. This knowledge can be constitute the kernel theories (theories from natural or social sciences) [24] or practitioner-in-use theories [25].

Proposing/refining design principles. During the process of deriving the design principles, a transition from the kernel theories to the context of information systems (IS) design results in an increase in specialization (or concretization) of the theories' constructs [26]. Design principles provide a rationale by relating the specialized independent variables (cause) to IS design requirements or goals (effect).

Testing design principles. To test the effects of the proposed principles, an IS artefact can be instantiated following the design principles, and then tested if the instantiated IS artefact satisfies the requirements. To instantiate the design principles, design items need to be defined as the IS features, that are, a particular instantiation of the specialized independent variable [27]. Design items are chosen from a set of alternatives and are thus subject to reasoned preferences [27].

DSR evaluation can be performed either ex ante (before) or ex post (after) the design of the IS artefact, as well as artificially or naturalistically [28]. Artificial evaluation is not limited to a specific technology solution in experimental settings, but instead can include simulated settings where the technology solution (or its representation) can be studied under substantially artificial conditions. Naturalistic evaluation explores the performance of a constructed solution technology in a real environment (i.e., within the organization) [28]. In this study, an *ex ante* artificial evaluation is conducted to test the effectiveness of design principles by potential end users. This evaluation will potentially reduce cost by repairing technical issues before any actual implementation of the design principles in DOHS.

3   DOHS Principles

3.1   Perception of Privacy Risk

Much of the value of the services offered by DOHS rests in the confidential and personal data about the health, identity, and practices of employees. Therefore, the possibility that this personal data might be used by the employer or a third party for discriminatory purposes is a threat to employees' privacy. Employees' perceptions regarding this risk could lessen their willingness to accept the technology [9, 10]. In addition, organizations need to consider employee privacy when incorporating these systems into the workplace because such integration could lead to legal issues. Therefore, the concept of information privacy must be cautiously addressed when specifying DOHS's technical and organizational requirements. On the technical side, designers should base their considerations on privacy-aware monitoring architecture and the adaptation of established authentication techniques. On the organizational side, decision makers must understand that a radical shift in the way employees think about these systems is needed.

The adoption of these systems is an incremental process of influencing individuals' perceptions of risks to their privacy. Throughout this process, employees need to be properly educated on what is and is not being monitored, what data are collected, and how those data are secured. Correspondingly, beyond the technical requirements, this research seeks to understand the effects of different functionalities and features that may influence employees' perceptions of privacy risk. Individuals' decisions regarding their privacy involve complex psychological processes wherein they engage with multiple considerations [29]. Consequently, a variety of theories have been employed in the effort to gain a deeper understanding of the factors that influence their perceptions [29]. Procedural fairness [30], social presence [31], and social response [32] theories are all models that have been adopted to illustrate the impact of institutional factors on privacy concerns. This study is grounded in these theories, and the design principles are formulated to positively influence employees' risk perception.

Procedural fairness, also known as procedural justice, refers to an individual's perception that a particular activity in which they are participating is conducted fairly [30]. It has been argued that the following constructs facilitate fairness: informing the individual about different activities of the interaction; seeking his or her consent to get involved in the activity; and providing s/he the power [33]. In the context of DOHS design the specialization (or concretization) of the procedural fairness theory results in the following design principles and corresponding design items to apply the principle:

Design Principle: DOHS should feature social fairness (notice, consent, and controllability of the employees' personal information) to reduce employees' privacy-based risk perception.

Design Item: Noticing the employee regarding their personal data collection, use, dissemination, and maintenance.

Design Item: Seeking employees consent for the collection, use, dissemination, and maintenance of employees' data.

Design Item: Providing mechanisms which employees can control the access, correction, and redress regarding DOHS's use of data.

Social presence theory proposes that the elevated level of social presence through richer media increases trust and approval of the content communicated [34]. For the case of privacy risk perception, people generally feel a stronger level of trust when they engage in face-to-face or video-supported communication because it allows them to use signs such as eye contact, body gestures, and facial expressions. Adapting this theory to the context of DOHS, the relevant design principle and the applicable design items would be the following:

Design Principle: Richer media should be used instead of text-based privacy statements to reduce employees' privacy-based risk perception.

Design Item: Using human embodiment (e.g., the supervisor) to announce the privacy statement.

Design Item: Using a rich media (e.g., videos) to announce privacy policies in addition to the text version of privacy statements.

Finally, social response as another institutional factors adopted in information privacy literature is about the tendency to disclose in response to a prior disclosure which is known as the principle of reciprocity [35]. In order to achieve this reciprocity for the case of DOHS, it is important for employers to openly communicate and share how they are going to use the data for the benefit of employees – and not against them – and regularly communicate the outcome of their DOHS use. The design principle and the design items based on this theory would be the following:

Design Principle: DOHS should feature a medium that facilitates an open sharing and communication of an organization's approach to their use of DOHS, to reduce employees' privacy-based risk perception.

Design Item: Giving access to employees a demo of employers interface (dashboard) to follow which aspect of employee's health and his environment have been monitored and how it has been used.

Design Item: Providing a list of actions that have been considered to be taken to improve the employees' wellbeing in the organization based on the data gathered by DOHS.

3.2   Work/Life Integration

The integration of work and personal life through the use of DOHS could result in conflict [37]. Electronic integration of the professional and personal is in contrast with many individuals' preference of keeping their public and private lives separate [38]. Findings of previous studies on employees' concerns related to this issue indicate that the use of these types of devices may also cause role conflict and work interruptions [39].

Role Conflict: By altering the scope of the activities undertaken in the work environment, DOHS could make it difficult for employees to balance their public and private roles; the result would be role stress, triggered by role overload and conflict [36]. Role conflict has been defined as incompatibilities among the demands of the employee's work environment, such as contradictory expectations and inadequate resources for performing tasks [37]. Adoption of DOHS could result in role conflict, in which an employee must find a balance between conflicting work and leisure demands. Using DOHS at work means that an employee would have to use worktime to take care of their personal wellbeing, which is not usually defined as a work task. To prevent or at least manage this conflict, DOHS would need to create a border between the employee's private (their responsibility for their own health and wellbeing) and professional roles while at work [38]. Following the model of coping with role conflict [39], this border could be created in two steps: structural and personal role redefinition.

Structural role redefinition can be accomplished through "communication with [the] role sender and [by] negotiating a new set of expectations, which will be mutually agreed upon" [39]. Within this step, organizations must define an acceptable time limit for interactions with the system, which will serve as a temporal border [38] for DOHS use in the work environment. Personal role redefinition can be achieved by changing one's

attitude towards role expectations, avoiding overlapping roles, or setting priorities among and within those roles. It can also be achieved by blocking DOHS influences that fall outside of an accepted temporal border and, at the same time, allowing a controlled amount of flow for necessary interactions [38].

Design Principle: Organizations should define the temporal border for the use of DOHS and limit the interaction to necessary interactions during work time.

Design Item: Noticing the employee about the limited time of interaction with system (e.g. checking the dashboard and other dedicated wellbeing features on the system).

Design Item: Limiting the DOHS interaction with employees to necessary alerts out of the accepted time span.

Work Interruption: While employees' interactions with DOHS resulting from intentional acquisition (for instance, by checking their performance on their personal dashboard) will be limited, they can still receive information without actively looking for it. Such passive interactions (alerts, recommendations, reminders, etc.) might demand non-work activities (e.g., taking a break, drinking water, competing with col-leagues, etc.), and thus could interrupt work-related tasks. Repeated interruptions can be distracting, adding to the required level of related cognitive effort; this, in turn, could lead to an almost automatic dismissal of most alerts, including those that are safety-critical [40].

This study proposes certain DOHS design principle geared towards managing work interruptions, following the "Interruption Evaluation Paradigm" applied in human/ computer interaction (HCI) [41]. The Interruption Evaluation Paradigm is an attempt at managing interruptions based on the social or cognitive context of the person being interrupted, as well as factors related to the content of the interruption. Only the most severe warnings are allowed to be sent and, thus, interrupt work [42]. The cognitive context includes all aspects of the receiver's mental level of involvement in a task [42]. The social context includes all aspects of the receiver's immediate environment, as understood in a social sense; this would include the place the individual is in, the people present within that place, and the social nature of the activity occurring [42]. The following design principle and design items are based on adapting this paradigm to DOHS applications.

Design Principle: DOHS should support the prioritization and filtering of interactions based on different levels of severity of the content (the relational context) and the employee's social and cognitive context, in order to reduce unnecessary interruptions.

Design Item: Filtering the low-severity alerts when employee is cognitively or socially overloaded.

Design Item: Putting the user in control of managing interruptions (e.g. the format, block the interaction in specific time, etc.).

3.3   Validation: Testing the Design Principles' Effectiveness

Data Collection

An *ex ante* artificial evaluation of principles can be performed by means of one particular instantiation. There are several prototyping techniques for instantiating a design architecture. Prototypes are defined as the means of examining design problems and evaluating solutions [43]. The right prototyping technique depends on what that technique is meant to emphasize; they vary from high fidelity, "a finished looking (or behaving) prototype," to low fidelity, "such as storyboarding and paper-based prototyping." Low fidelity prototyping techniques are considered to be most effective when the goal is to describe what an artefact could do for a user, rather that how it would look [43]. Therefore, a low fidelity prototype was most effective for this study, since the goal was to assess how potential DOHS end users would examine the proposed design items, rather than testing the technical features of the system.

In this study, storyboarding was adopted as a low fidelity prototyping technique, in order to instantiate the design architecture proposed by the design items. Storyboarding helped to direct the focus of the audience to the scenarios communicated, and kept them from being distracted by technical and logistical details. In addition, the stories stimulated their imagination and helped them to fill in missing details the designers did not include. The focus of each story was the user, what they did and perceived, and what the experience meant to them [44]. The storyboards provided a design space for the narrative visualization of users' interactions with this type of system, as well as the critical contextual aspects over time [45]. Key elements of any storyboard are the inclusion of people, their actions, and emotions, the depiction of time, inclusion of text, and a level of detail [46].

In order to verify the effectiveness of the proposed principles, a survey study was conducted using these storyboards. Each relevant design item from the principles was presented as a scenario (see Fig. 1). The privacy risk perception storyboards were administered first. Next, respondents were asked about the effectiveness of the storyboards in presenting role conflict coping strategies. Finally, the work interruption management storyboards were administered. For each, respondents were asked to rate the effectiveness of the scenarios on a 1 to 5 scale (1 being the least effective, and 5 being the most).

At the introduction of Active@work, Anna, the head of department introduces the company's expectations of adapting Active@work and announces the Active@work privacy policy.	Anna lets the employees ask their questions regarding the data collection, use, dissemination, and maintenance by organization. Anna specifically articulates the purpose or purposes for which the data is intended to be used.	Later, Nico is sitting in his office and wants to start using Active@work. Before, he can review the privacy policy by either reading it or by watching a short video.

Fig. 1. Social presence storyboard.

Respondents were recruited through the researchers' website and by e-mail, resulting in a sample of 78 responses. The sample characteristics are summarized in Table 1. Out of the total sample, 44.78% were female and 50% were male; 5.20% did not indicate a gender. Half of the respondents ranged between 35 and 55 years of age. The respondents were mainly employed in engineering (24.35%) or IT-related (33.33%) positions. Most were regular office workers (44.78%) or low-level managers (20.51%).

Table 1. Sample characteristics (n = 78)

Characteristics	N	%	Characteristics	N	%
Gender			*Age*		
			Under 25	4	5.12
Female	35	44.78	26 to 35	32	41
Male	39	50	36 to 45	29	37.17
NA	4	5.20	46 to 55	9	11.53
Job level			Over 55	1	1.20
			NA	3	3.84
Executive	3	2.84	*Job function*		
Vice president	2	2.56	IT	26	33.33
Manager	11	14.10	Support services	6	7.69
Associate	2	2.56	Marketing/Sales	7	8.97
Team leader	16	20.51	Engineering	19	24.35
Team member	35	44.78	Finance	2	2.56
Intern	2	2.56	Administration	5	6.41
Other	5	6.41	Other	12	15.38
NA	2	2.56	NA	1	1.20

Results

In general, all of the storyboards were perceived as effective for intervening in privacy risk, role conflict, and task interruption issues. On average, the respondents assessed the effectiveness of all of the storyboards as moderately high (all were ranked above 3.40). Among the three scenarios proposed to reduce employees' apprehension of privacy risk, procedural fairness (PF) received the highest ranking (with a mean of 3.98). Social presence (SP) and social response (SR) were also perceived to be effective, and their means were 3.42 and 3.55, respectively. The two proposed coping strategies for managing role conflict received similar rankings to one another. On average, structural redefinition (SR) was rated 3.37, and personal redefinition (PD) was ranked 3.40. With regards to interruption management principles, automated interruption management (AI) was rated lower (with a mean of 3.51) than manual interruption management (with a mean of 3.89).

One way to assess the comparability of a multi-item survey is to assess whether items that are supposed to measure the same construct correlate with one another. It should be noted that correlations among principles designed to reduce employees' apprehension associated with privacy risk were relatively high (all above 0.43). The

correlation between SD and PD was also high (0.61). However, the correlation between AI and MI was relatively low (0.31), due to somewhat different ways of approaching interruption prevention. In an automated interruption management scenario, employees are passively involved, while in manual interruption management, empowering employees to control interruptions forces them to be actively involved. The mean scores, standard deviations, extracted variances, and inter-item correlation estimates are all summarized in Table 2.

Table 2. Inter-item correlations, means, standard deviations and variances

	SP	SR	PF	SD	PD	AI	MI	Mean	SD	Variance
SP	1.00							3.42	1.01	1.03
SR	0.43	1.00						3.55	1.08	1.17
PF	0.53	0.47	1.00					3.98	1.01	1.03
SD	0.28	0.35	0.17	1.00				3.37	1.15	1.34
PD	0.29	0.42	0.30	0.61	1.00			3.40	1.12	1.26
AI	0.22	0.40	0.25	0.31	0.46	1.00		3.51	1.14	1.30
MI	0.22	0.30	0.34	0.33	0.49	0.31	1.00	3.89	0.98	0.96

4   Discussion and Conclusions

This study proposed a set of principles for the design of DOHS, following a DSR paradigm. These design principles are expected to reduce privacy concerns and the additional mental pressure caused by such systems that – if left unchecked – would significantly diminish an employee's willingness to use such devices while at work. The effectiveness of these principles was tested by querying potential end users.

Grounded in kernel theory from social science, this study attempted to reduce apprehension related to perceived risks to employees' privacy, by using technical and organizational features to embed more social responses, presence and fairness interventions in DOHS. To avoid role conflict, employers should commit not only to providing the devices, but also to allocating an acceptable amount of time for employees to interact with those devices. Systems designers should provide features for limiting access to the devices outside the acceptable time window. However, even though active interaction (e.g., checking the dashboard, playing games, and other dedicated wellbeing features) can be limited, passive interaction (e.g., receiving alerts and recommendations) should not. Such passive interactions, however, should not interrupt employees' work activities. Therefore, as evidenced by the Interruption Evaluation Paradigm of HCI, there is a need for two different levels of interruption management. One should feature an automated reduction of excessive alerts, based on an analysis of the user's context and the importance of the interruption. The other should give the employee full power to manage and control interruptions, when needed.

Being limited to a primarily conceptual level, the focus of this study is on the theoretical underpinings of the design principles. Therefore, further research instantiating these principles to actual DOHS implementations will need to be undertaken.

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