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Designing visualizations for workplace stress management: Results of a pilot study at a Swiss municipality

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Abstract. Job absenteeism and health problems are frequently caused by elevated exposure to work-related stress. The public sector is particularly affected by this development. Nevertheless, public sector organizations seem to have issues to reliably detect stress or to discuss about this topic in an objective and factual manner. Data visualizations have been found to be a powerful boundary object for sense-making and for unraveling issues that lie under the surface. Based on a pilot study at a medium-sized municipality in Switzerland, we thus developed, tested, and discussed various alternative visual representations for creating awareness about occupational stress. The results of this study showcase the hidden potential and perils of analyzing physiolytics data on aggregate level.

Keywords: Data visualization • physiolytics • stress management • well-being

Preferred conference track: General e-government & open government track

1 Introduction

An increasing number of organizations are implementing wearable technologies such as biosensors, activity trackers or emotion trackers to monitor the physical and psychological well-being of their employees [1]. In private settings the development of these low-priced and ubiquitous systems (which in this article we will refer to as *physiolytics* [2]) has had great success and led to the formation of the "quantified-self" movement, which now slowly is arriving to the public sector as well. More and more public sector organizations are nowadays trying to seize the opportunity of collecting a broad range of biological, behavioral and other type of data. For example, prior research reports on the use of physiolytics, amongst others, in the areas of air traffic control [3], public transportation [4], firefighting [5], but also in regular office settings [6, 7]. The introduction of physiolytics devices in the workplace constitutes an upward trend: from a total of 485 million devices estimated to have been sold in 2018, more than 13 million were used in occupational health and safety programs [8].

Given that work absenteeism and work-related diseases are on the rise in the public sector, distributing physiolytics devices among public servants could be a first measure to increase the personal consciousness of possible health and safety threats from elevated stress levels, sedentary behavior, or other unhealthy work habits. However, the organization as a whole might waste an important opportunity to systematically reflect, analyze, and thematize work-related health issues in the public administration if the collected sensor data is not exploited on an aggregated level. In this paper, we therefore set out to develop different data visualizations for composing a dashboard for stress management. Data visualizations have been found to be a powerful boundary object for sense-making, decision-making, or problem-solving [9]. For that matter, and against the backdrop of increasing health expenditures due to stress-related absenteeism in the public sector, we conducted a longitudinal pilot study at a medium-sized municipality in Switzerland in order to showcase how to purposefully use sensor data collected from physiolytics devices. In this paper, we want to deal with the question of how to visualize common physiolytics data as a means to creating awareness about work-related stress given that it frequently remains unnoticed or undiscussed in many public administrations.

2 Background

Physiolytics creates opportunities of rethinking and re-enacting health and well-being in the public administration, as it enables civil servants to have a data-driven approach to reflect and respond to health issues. Such systems track and record parameters like heart rate, body temperature or sleep, with the view to give a quick and easy access to information about one's health or performance. Characterized by their automaticity, autonomy and minimal costs in gathering large amounts of data, sensors constitute the key components of physiolytics [10-12]. However, just collecting large volumes of data is not sufficient for creating considerable value. For that to happen, sensor data needs to be transformed into a form (i.e. textual and visual representations) that is easily accessible and comprehensible [13].

Prior research shows that particularly data visualizations have a transformative effect: they drive individuals to reflect and eventually act in response to the represented data [14]. By translating sensor data into comprehensible visual representations, issues with health and well-being become more legible, accessible and foreseeable [15]. Therefore, they may help users to perform more punctuated health behavior changes because the action is based on informed insights of individual lifestyle issues rather than on subjective experiences [12]. To sum, visual representations are critical to our ability to process complex sensor data and to build better intuitions as to what aspects improve and what worsens health [16].

But how to do it? In the extant literature, we find a variety of meta-requirements that may guide the design of generic data visualizations [17, 18]:

- *Accurate*: Measures and quantities have to be accurate, so that users are ensured that they can exploit the health information that is displayed.
- *Easy-to-read*: A visual salience between metrics is desired. Still, superfluous features (e.g. flashy colors) or unnecessary components (e.g. side illustrations) should be avoided, as it may interfere with cognition.
- *Easy-to-understand*: Visualizations have to disseminate information to the general public. Users are not likely to be data scientists.
- *Clear and concise*: Too much information may hinder cognition.
- *Logical*: Visualizations have to be organized in a simple and logical way, so that users can promptly perceive the information displayed.
- *Meaningful to target audience*: The information provided has to resonate in the context of target audience.
- *Allow comparison*: Visualizations have to make it possible to easily compare quantities, relationships etc.
- *Convincing*: Visualizations should nudge users in exploiting the information.

Apart from the above mentioned meta-requirements, the literature has notably discussed the introduction of interactive visualizations [19], examined the insights they provide on use practices [15], or even conceptualized the creation of custom visualizations [20]. However, in most cases, there is a presupposition that data is accessible in their globality and that related visualizations can provide information without restriction. As most of the current literature on physiolytics is focused on medical professionals or on lifestyle consumers, the display of personal data (as well as its collection and manipulation) is primarily concerned with the perspective of a single individual. Little is known about the use of such data for organizational purposes, with the aim to build a big picture of the existing health and well-being status and to raise awareness and instigate individual or group action within an organization.

Privacy policies and data protection laws hinder organizations to establish a direct use of physiolytics to operate with sensitive and highly personal health-related data. In this context, it is important to differentiate two things: “medical information” that may reference health statuses and/or help to retrace medical conditions (e.g. continuous blood glucose monitoring or variation in one’s heart rate) and non-invasive information such as step counting, minutes of activity or calories burned. Medical information is typically subject to confidentiality requirements regardless of how the employer obtains this information. On the other hand, non-sensitive health information does commonly not depend on constraints on disclosure [21]. Yet, evidence seems to indicate that the nature of tracked data may not be, in practice, the main source of concern for employees as regards their privacy. Prior research [22] has shown that metrics, such as air quality, noise, activity or mood have different degrees of privacy concerns for employees (e.g. air quality was projected to be less "problematical" than mood). Nonetheless, research indicates that privacy concerns were not primarily linked to the type of data collected but are rather linked to the level of anonymity that was provided respectively the concern of employees to lose their anonymity [23]. In sum, adding a new level of granularity in visualizations that ensures users that they will not be identified, could break down most barriers as regards to privacy concerns. Designing data visualizations in the workplace is therefore a matter of effectively erasing the individual, to focus on visualizations that apprehend group levels. We thus define some additional meta-requirements:

- *Non-identifiability of individual employee*: Employees have to feel that they are able to manage their level of intimacy and speech at work.
- *Transparency:* An employee should be able to identify what data are collected and how that may be used visually, in order to develop a form of user trust. This user trust builds upon the feeling that there is no manipulation in the data displayed and that sensor data visualizations are done for the common good in the workplace.
- *Community-oriented and participative design*: The design has therefore to be community-oriented and create potential for participation from users (e.g. possibility to include self-reporting data).
- *Rooted in the organizational context and culture*: Visualizations have to fit the general attitude towards sensors, with a capacity of adaption upon the interests, concerns or requests of employees (e.g. employees might prefer visualizations oriented on activity levels rather than stress levels). Same goes for an attention to the specificities of the workplace environment.

3 Methodology

Developing visual representations is a real-world problem that requires both, a technological and social viewpoint (i.e. practice-inspired research). On the one hand, we need to understand the possibilities and limitations of data management and responsiveness of physiolytics devices. On the other, we need to get a grasp on what is feasible, desired, and acceptable in an organizational context. In approaching this problem, we chose to apply *Action Design Research* (ADR) [24] to combine both a systematic thinking on designing an artifact (i.e. in our case a dashboard) with a human-centered lens regarding the emergent social dynamics which occurs when confronting users with unknown and/or highly sensitive solutions.

A particular characteristic of ADR is the preference of authenticity over controlled settings [24]. Accordingly, ADR is often conducted in field studies where the design of new artifacts is performed in a real-world setting, in a participatory manner together with dedicated users and/or pilot organizations [25]. In this sense, researchers and practitioners form what Sein and colleagues refer to as "*ADR team*" whose initial goal is to develop a mutual understanding of the scope, focus, and mode of inquiry before starting to build solutions. Contextual factors are supposed to play an important role in knowledge creation [26, 27].

In order to purposefully visualize physiolytics data for creating awareness about work stress in organizations, we chose to apply an *IT-dominant building, intervention, and evaluation logic*. This means that our initial focus was on developing different versions of visual representations and then improve selected design variants by continuously instantiating and repeatedly testing assumptions, expectations, and knowledge about and with users and their use environment. In this paper, we report on the findings from our *first design iteration*. Our pilot partner was a medium-sized municipality in Switzerland. Participation in our field study was voluntary for local administrators. We informed them before-hand about the specific goals of our project as well as about data privacy, security and functioning of physiolytics devices. We opted for a medical wearable (i.e. CE class IIa device) that is capable of accurately measuring a range of different parameters, amongst others heart rate, blood oxygenation, skin temperature, skin blood perfusion, respiration rate, heart rate variability, blood pulse wave and others (see Figure 1).

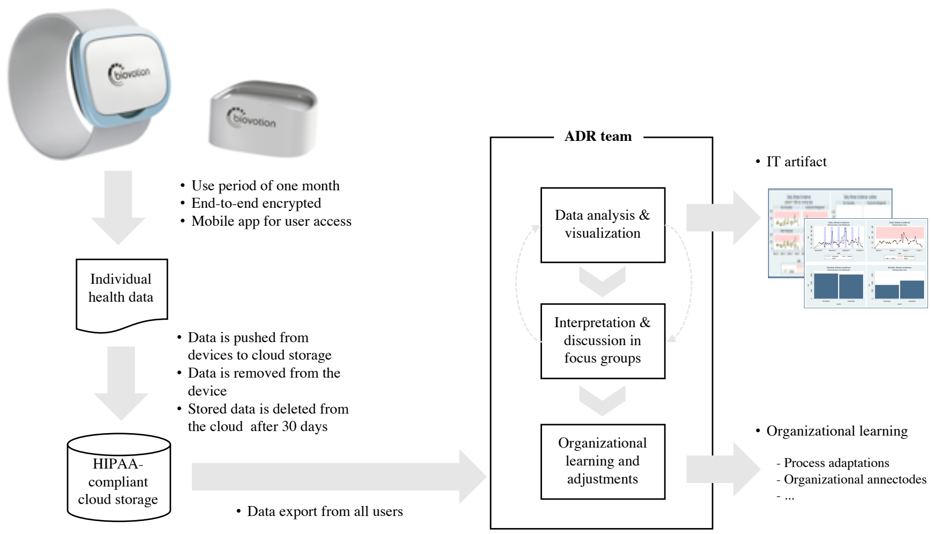

Fig. 1. Procedure of one ADR design iteration

A total of 20 local administrators (composing our ADR team) were equipped with the device during a one-month test period. We provided them with clear instructions on how to wear the device, how to access the stored personal data and how to secure the data to a HIPPA-compliant cloud storage. After this test period, we exported the collected, but anonymized data of all participants and developed multiple visual representations with the aim to capture some proxy for "stress" for the specific departments of the municipality and the organization as a whole.

To learn about both, the practical day-to-day issues with the medical wearables and the comprehensibility and accuracy of our developed data interpretations, we conducted a focus group session at the end of our design iteration. We opted for this format of inquiry as it offers a great flexibility and large amounts of rich data that can be used for artifact refinement [28]. Due to restrictions of length, in this paper we report only on the technical part of our research.

4 Results

4.1 Observing "stress" on organizational level

In the course of our pilot study, we developed various visualizations to capture "stress" on organizational level. According to our theoretical findings, and in compliance with inputs from practitioners from our ADR team, the desirable properties were (1) non-identifiability of individual employee; (2) creation of "stress" measurement comparable over time; (3) reflection of local "stress" trend in the organization; (4) establishment of risk and safety intervals. Non-identifiability is achieved by aggregation of individual stress incidence on group level.

To develop stress measurement comparable over time, we created the Weighted Stress Incidence (WSI) indicator. It communicates the following information: how much of "stress" does an employee in organization experience per one hour of device use over a specific day on average. The amount of time each employee uses the device and the number of actual users is variable (not constant). Thus, the "Total Stress Count" is not directly comparable from one period to another. WSI incorporates those variables improving comparability over time compared to "Total Stress Count". Moreover, some employees wear devices during weekends when measurements may not reflect "work-related stress". WSI during weekends should be distinctive from WSI during working days on the dashboards.

A proper approximation of a stress trend in organization is achieved by displaying of polynomial trend function. A risk zone is defined above a 90th percentile of historical data. Safety zone is defined above a 90th percentile of historical data. This is again an arbitrary criterion for displaying risk and safety zones.

Figure 2 displays WSI at organizational level. Left side of the visualization takes into account measurement from both working days (white background) and weekends (purple background). The right side of the visualization considers only working days. The upper part displays daily WSI in a line plot. The bottom part illustrates monthly sums of WSI in a bar plot. Red polynomial trend shows that on middle of November, beginning of December, it was the most "stressful" period in the municipality overall while from middle of December onward it was in decline again. The majority of observations are in the safety zone. During the weekends employees typically get more "stress" then during working hours (note: we explicitly interdicted participants to wear the device during leisure time). From the focus group discussion, we know that there has been a special occasion which required some administrators to work over weekends which could explain the higher stress levels). Overall November and December are equivalent in terms of WSI at organizational level.

Fig. 2. Stress measurement on organizational with the Weighted Stress Incidence (WSI)

4.2 Observing "stress" on departmental level

Given that stress is not distributed equally among all the employees, a highest order aggregation (organizational level) may degenerate quality of stress indicators when there are a lot of employees in the unit of aggregation. For example, when 100 employees are "stressed" and 100 are relaxed, an average employee feels fine when data is aggregated. Therefore, for getting a more precise picture we introduce an additional visualization on a lower aggregation unit: organizational departments. This illustration relies on the same properties as the previous graph and additionally includes a display of outliers.

Figure 3 depicts the WSI on the departmental level. The left side incorporates working days only. It excludes outliers for better visibility of measurements shown on the same scale for each department. It shows that different departments have different stress-related patterns. For example, the City Chancellery has an upward stress trend, whereas the Construction Management department is close to the straight line. It also shows that the Tax Office experienced a lot of stress, particularly at the end of November and in the first half of December, reaching a risk zone. Persistent and long-time stay in a risk zone may be a signal for management to launch a psychosocial intervention [29] in order to improve employees' well-being, reduce stress and improve work-related performance. Further, on the right side of Figure 3, we see the outliers of a department. There is one observation that lies remotely from others in the Tax Office. However, one single measurement may be caused by a one-time event and it does not have a strong impact on the "stress" trend overall.

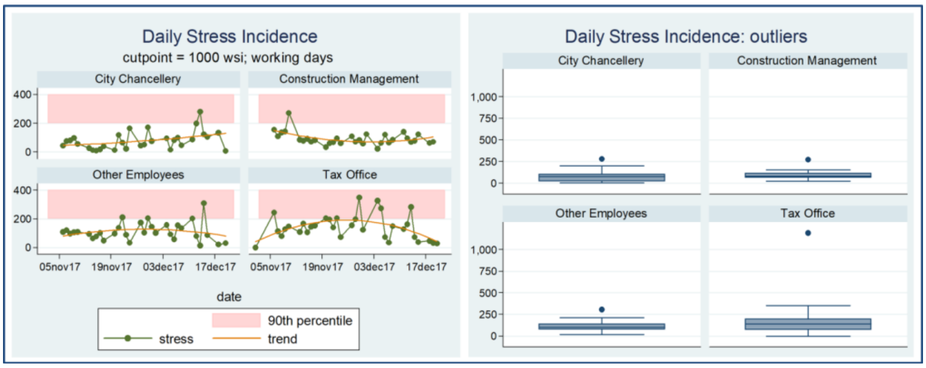

Fig. 3. Stress measurement on departmental level

4.3 Reflecting on the reliability of the data for measuring organizational stress

Correct inferences and proper responses to elevated stress can only be developed, when the data basis is reliable. Hence, we propose to take a closer look at the motion activity (MA), that is the average value of motion intensity per hour, and the frequency of use, that is the amount of time a user spends wearing a device per day.

Right side of Figure 4 shows MA. When MA distribution is close to uniform having low variability over time (see the case of the City Chancellery), a dynamical change in WSI trend most likely happens to be due to emotional stress and other components. When MA is not uniform and fluctuates (see the case of the Tax Office) a change over time in WSI may be due to combination of MA, emotional stress and other conditions. The fact that MA is not always uniform across departments shows that we need to take it into account when interpreting stress-related indicators for users of physiolytics devices, because BPW is reactive to motion intensity.

Left side of the Figure 4 shows that users were not always wearing our distributed devices uniformly during the pilot study. The frequency of use fluctuates. This gives us some indication about the reliability of measurement. First of all, stress measurement should be done per a fixed unit of time (like in case of the WSI) to provide comparability of measurements from one period to another. Moreover, if users spent only little time with the device per day, we may have obtained inaccurate or biased stress-related measurements. Therefore, it may be reasonable to exclude observations or only make cautious inferences about the stress level of a particular department. In the end, the goal is always to make use this information to make some positive changes in the public administration. It could be highly counterproductive to act upon wrong assumptions.

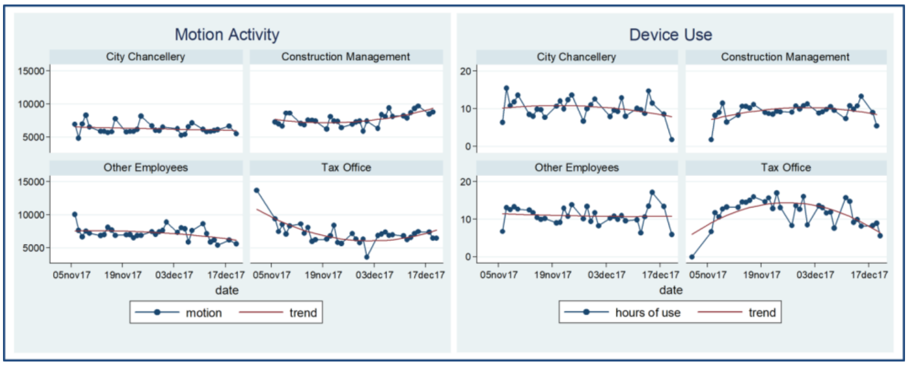

Fig. 4. Device use and motion activity during working days

5 Discussion

The goal of this paper was to show how sensor data collected from physiolytics devices could be purposefully visualized for creating awareness about work stress in the public administration. We did so because stress-related absenteeism is on the rise in the public sector and there is often no dialogue happening about this matter. Based on a pilot study in a medium-sized municipality in Switzerland, we wanted to showcase some early reflections on how to analyze and visualize "stress" on organizational and departmental level in order that occupational health and safety programs can respond more precisely to health and safety risks.

As with all design-oriented research, this work is iterative. There is still long way ahead of us and we especially need more in-depth testing together with the deployment of our solution to other branches of the public sector in order to get a more nuanced view. Particularly, we need to further evaluate the perceived utility and effectiveness in creating health awareness among employees and its influence on work absenteeism and other effects.

Another limitation of this work is also the interpretability of visualizations. The developed visualizations and indicators reflect a specific organizational and technical context. For instance, the developed indicator WSI is based on the BPW which is reactive to various stress-related conditions (and also bound to a specific physiolytics device). Improving separation between various components connected to stress, such as physical stress (intensive motion), emotional stress, hypertension, certainly will improve the quality and interpretability of stress-related indicators. It is still necessary to do a cross-validation of stress-identification procedure that serves for creation of any group-level metrics related to stress.

Furthermore, it is advantageous to consider alternative biological metrics having stronger links to stress, such as cortisol and galvanic skin response. For this, we would have to wait for new and affordable devices that are able to measure this (note: as for now, existing solutions are expensive; accordingly, it is not very likely that these solutions are adopted by organizations for the entire workforce any time soon).

As with any technology, continued use is key. In order to be able to accurately depict organizational stress levels, we also need to find ways to counter the usual loss in motivation (even by employees who initially supported the adoption). Also, it is necessary to reflect about how to set up an occupational health program that uses physiolytics devices in a meaningful way and how to guide change initiatives based on our proposed dashboard for stress management. This is particularly in the spirit of ADR which not only aims at designing IT artifacts but also systematizing organizational learning. Lastly, we have to address the question of the tangible impacts of dashboards in terms of health behavior change. Will more precise information and a higher health awareness really lead to noticeable effects? Answering these questions is of particular importance given that public organizations certainly expect a return on the investment (return on tax-money) of physiolytics devices and data analytics platform.

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References

1. Tetrick, L.E., Winslow, C.J.: Workplace stress management interventions and health promotion. Annual Review of Organizational Psychology and Organizational Behavior 2, 583-603 (2015)
2. Wilson, H.J.: Wearables in the workplace. Harvard Business Review 91, 23-25 (2013)
3. Rodrigues, S., Paiva, J.S., Dias, D., Aleixo, M., Filipe, R., Cunha, J.P.S.: A wearable system for the stress monitoring of air traffic controllers during an air traffic control refresher training and the trier social stress test: A comparative study. The Open Bioinformatics Journal 11, 106-116 (2018)
4. Rodrigues, J.G.P., Kaiseler, M., Aguiar, A., Cunha, J.P.S., Barros, J.: A mobile sensing approach to stress detection and memory activation for public bus drivers. IEEE Transactions on Intelligent Transportation Systems 16, 3294-3303 (2015)
5. Lee, T.-G., Lee, S.-H.: Safe sensing network system and evaluation for emergency information services. Wireless Personal Communications 79, 2425-2438 (2014)
6. Han, L., Zhang, Q., Chen, X., Zhan, Q., Yang, T., Zhao, Z.: Detecting work-related stress with a wearable device. Computers in Industry 90, 42-49 (2017)
7. Otenyo, E.E., Smith, E.A.: An overview of employee wellness programs (EWPs) in large U.S. cities: Does geography matter? Public Personnel Management 46, 3-24 (2017)
8. Giddens, L., Gonzalez, E., Leidner, D.: I track, therefore I Am: exploring the impact of wearable fitness devices on employee identity and well-being. In: Proceedings of the 22th Americas Conference on Information Systems, pp. 1-5. (2016)
9. Matheus, R., Janssen, M., Maheshwari, D.: Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities. Government Information Quarterly, forthcoming, (2019)

10. Lupton, D.: Beyond techno-utopia: Critical approaches to digital health technologies. Societies 4, 706-711 (2014)
11. Mettler, T., Wulf, J.: Physiolytics at the workplace: Affordances and constraints of wearables use from an employee's perspective. Information Systems Journal 29, 245-273 (2019)
12. Swan, M.: Sensor mania! The internet of things, wearable computing, objective metrics, and the quantified self 2.0. Journal of Sensor and Actuator Networks 1, 217-253 (2012)
13. Oh, J., Lee, U.: Exploring UX issues in quantified self technologies. In: Poroceedings of the 8th International Conference on Mobile Computing and Ubiquitous Networking pp. 53-59, Hakodate, Japan (2015)
14. Ruckenstein, M.: Visualized and interacted life: Personal analytics and engagements with data doubles. Societies 4, 68-84 (2014)
15. Pantzar, M., Ruckenstein, M.: The heart of everyday analytics: Emotional, material and practical extensions in self-tracking market. Consumption Markets & Culture 18, 92-109 (2015)
16. Fox, P., Hendler, J.: Changing the equation on scientific data visualization. Science 331, 705-708 (2011)
17. Marcengo, A., Rapp, A.: Visualization of human behavior data: the quantified self. Big Data: Concepts, Methodologies, Tools, and Applications, pp. 1582-1612. IGI Publishing, Hershey, USA (2016)
18. Fawcett, T.: Mining the quantified self: personal knowledge discovery as a challenge for data science. Big Data 3, 249-266 (2015)
19. Larsen, J.E., Cuttone, A., Jørgensen, S.L.: QS Spiral: Visualizing periodic quantified self data. In: Proceedings of the 2013 CHI Workshop on Personal Informatics in the Wild: Hacking Habits for Health & Happiness, pp. 1-4, Paris, France (2013)
20. Choe, E.K., Lee, N.B., Lee, B., Pratt, W., Kientz, J.A.: Understanding quantified-selfers' practices in collecting and exploring personal data. In: Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems, pp. 1143-1152, Toronto, Canada (2014)
21. Moore, P., Piwek, L.: Regulating wellbeing in the brave new quantified workplace. Employee Relations 39, 308-316 (2017)
22. Mathur, A., Van den Broeck, M., Vanderhulst, G., Mashhadi, A., Kawsar, F.: Tiny habits in the giant enterprise: understanding the dynamics of a quantified workplace. In: Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 577-588, Osaka, Japan (2015)
23. Yassaee, M., Mettler, T.: Digital occupational health systems: What do employees think about it? Information Systems Frontiers, forthcoming, (2019)
24. Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Quarterly 35, 37-56 (2011)
25. Haj-Bolouri, A., Bernhardsson, L., Rossi, M.: PADRE: A method for participatory action design research. In: Proceedings of the 11th International Conference on Design Science Research in Information Systems and Technologies, pp. 19-36, St. John's, Canada (2016)
26. Avgerou, C.: The significance of context in information systems and organizational change. Information Systems Journal 11, 43-63 (2001)
27. Davison, R.M., Martinsons, M.G., Kock, N.: Principles of canonical action research. Information Systems Journal 14, 65-86 (2004)

28. Tremblay, M.C., Hevner, A.R., Berndt, D.: Focus groups for artifact refinement and evaluation in design research. Communications of the Association for Infomation Systems 26, 599-618 (2010)
29. Leka, S., Cox, T., Zwetsloot, G. (eds.): The European framework for psychosocial risk management. Institute of Work, Health and Organisations, Nottingham, United Kingdom (2008)