User-Perception of a Webcam-Based Intervention System for Healthy Habits at Computer Workstations

Angelina Clara Schmidt[1][a], Dimitri Kraft[2][b], Fabienne Lambusch[1][c] and Michael Fellmann[1][d]
[1]*Institute of Business Informatics, University of Rostock, Rostock, Germany*
[2]*Fraunhofer IGD, Rostock, Germany*

Keywords: Webcam-Based Intervention System, Healthy Habits, Computer-Based Work.

Abstract: Fueled by the ongoing digitalization, the amount of computer-based work is on the rise. Employees increasingly spend large parts of their day in front of computer workstations. While this type of work means less physical effort, it can nevertheless cause a range of health problems such as eye strain, back pain, wrist pain, and muscle fatigue and, in the long run, can lead to serious problems. Although some monitoring systems for health-related parameters have been developed so far, few of them provide interventions during work. Also, empirical insights on how users actually perceive such systems are still missing. Hence in our work, we report on first results regarding the user perception of such systems based on CareCam, a webcam-based system for health-promoting interventions. Based on user feedback from real-world usage of the system for one week, we derive insights for the further development of such systems.

1 INTRODUCTION

In many industries, machines have taken over the repetitive, physically strenuous and dangerous work while humans are still needed to perform administrative, management or creative tasks. In line with this, a proliferation of office work and sedentary work styles can be observed on a global scale (Park et al., 2020). The number of computer terminals in workplaces in Germany has even grown by almost 50% within the last decade (Fichter et al., 2012). In line with this, 40% of the employees in Germany are knowledge workers (Burkhart & Hanser, 2018) and half of the working population is using computers for work tasks (Bitkom, 2018). However, extensive computer-based work in conjunction with unfavorable work behaviors can lead to serious health problems. The most common computer-related health problems include visual problems such as eye strain and musculoskeletal problems such as back pain, wrist pain and muscle fatigue (Mary & Munipriya, 2011). Stress and headaches can also be triggered. These health problems of employees can even result in reduced productivity, prolonged absenteeism, and early retirement. Therefore, preventive and health-promoting support in the workplace can play an essential role in maintaining employees' health. It moreover offers the potential to take appropriate action in the early stages (Mary & Munipriya, 2011). Providing tools for managing and improving health can contribute to the companies' competitiveness and could even help to attract new employees.

With CareCam, an application that can record various health-related data via a simple webcam has been developed at Fraunhofer. This data can be used to identify health strains in the workplace and generate personalized health-promoting interventions. Nevertheless, it is unclear so far how such interventions can best minimize health risks at computer workstations and how users perceive them. Hence, this work aims to evaluate a concept for health-promoting interventions at computer workstations that has been integrated into CareCam. While the interventions have already been described from a more technological perspective in our previous work (Kraft et al., 2022), we here put emphasis on user perceptions regarding

[a] https://orcid.org/0000-0002-6967-4287
[b] https://orcid.org/0000-0002-0604-5854
[c] https://orcid.org/0000-0002-0303-1430
[d] https://orcid.org/0000-0003-0593-4956

Schmidt, A., Kraft, D., Lambusch, F. and Fellmann, M.
User-Perception of a Webcam-Based Intervention System for Healthy Habits at Computer Workstations.
DOI: 10.5220/0011776100003414
In *Proceedings of the 16th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2023) - Volume 5: HEALTHINF*, pages 567-580
ISBN: 978-989-758-631-6; ISSN: 2184-4305

these. To do so, we conducted a pilot study in which test users employed CareCam with the interventions in their everyday work environment. Based on semi-structured interviews, we provide insights into how users perceived different types of camera-based health-promoting interventions and if features were missing. We moreover also derive concrete possibilities for the improvement of future health-promotion systems for high-screen-time work.

The next section describes related work. Section 3 presents basic features of CareCam while Section 4 focuses on the interventions implemented. The case study preliminary results are presented in Section 5.

2 RELATED WORK

Most works in the area of camera-based health systems at computer workstations address ergonomics and focus on the detection and prevention of unhealthy sitting postures and durations (Herrera et al., 2021; Mary & Munipriya, 2011; Paliyawan et al., 2014 - 2014a, 2014 - 2014b; Taieb-Maimon et al., 2012) (for a review see (Kraft et al., 2022)). (C. Chen et al., 2012) present a rather comprehensive system, which uses a webcam and additional cameras at the workstation to provide feedback on the current ergonomic state of the worker. For this, parameters such as average work and break times, distance to the computer screen, head movements, gaze directions, and blink frequencies are recorded. The system learns the user's behavior patterns such as "close to the screen", "low head mobility", or "absent" and provides ergonomic reminders. Beyond sitting postures, some systems also provide features for *advanced monitoring of health-related parameters* such as heart rate, stress, or mood. For example, (Maeda et al., 2016) capture physiological information through the normal equipment of a computer workstation. In this process, the camera measures vital data such as heart rate, facial expressions, and eye blinks in order to present it in a visualization application. Another system in this direction has been developed by (Vildjiounaite et al., 2018), which can recognize stressful working hours. Finally, there are a few *systems that provide health-promoting interventions*. In this direction, (Taieb-Maimon et al., 2012) present an automatic feedback system that displays webcam photos of the current posture at work contrasted with photos of the correct posture, thus striving to continuously urge the user towards improving his or her posture. Also, (Herrera et al., 2021) have already introduced active breaks with exercises, but these are also only related to posture. The focus is on the automated control of the correct performance of these posture-related exercises.

In summary, existing research works and systems only provide monitoring and tracking features, or they provide health-related interventions, but only focus on single aspects such as posture. None of the research works contain information on how users perceive such a system during office work. Hence, we tested a set of health-promoting interventions in a real-world pilot study with subsequent interviews to gain information about user perceptions. Being aware of the users' valuation of interventions is of vital importance to ensure the further successful development of health-promoting intervention systems, since interventions that are not rated as pleasant and helpful by the user will not be used on a regular basis.

3 CareCam FEATURES

The interventions for our case study were implemented into the existing software CareCam (Kraft et al., 2021). CareCam enables the objective measurement of important vital data at the workplace using a simple webcam. This data comprises:

- Pulse rate and pulse rate variability
- Blink frequency
- Upper body posture
- Human emotion through facial expression recognition

Some representations of the measurements are displayed in real-time on a user interface. Although the interface was only relevant in our study to start and stop the software, the CareCam dashboard is shown in

Figure 1 to illustrate measurements. The top row shows the pulse rate in beats per minute and the pulse rate variability in milliseconds. Below that, a rating of the upper body posture as either "good" or "bad" is presented. Next to that, the distance of the eyes from the screen is displayed in centimeters. The bottom row shows the total number of blinks counted up. The proportion of different emotions is shown directly within the displayed camera image. We further detail the health interventions offered in the following section. All data of the system was stored locally. No data was sent to the outside, and no images or video streams were stored.

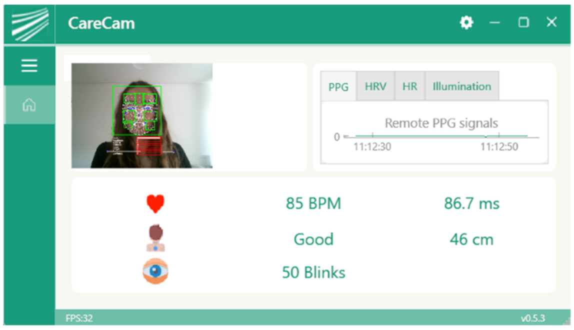

Figure 1: CareCam Dashboard.

4 DESIGN OF INTERVENTIONS AT COMPUTER WORKSTATIONS

To help understand the results of the presented user perception study, this section describes an extended version of the technical implementation of the intervention system that has already been described in our previous work (Kraft et al., 2022). For our study, two types of interventions have been explored: reminders and breaks. Several articles (cf., e.g. (C. Chen et al., 2012; Mary & Munipriya, 2011; Paliyawan et al., 2014 - 2014a)) already included initial forms of alerts or reminders as health-promoting methods. Hence, several instances of this intervention type were included, which are described in Section 4.1. In addition, (Herrera et al., 2021) have introduced breaks focusing on posture-related exercises. Since regular breaks are an important part of a healthy workday, breaks should be suggested to the participants in our case study, too. We decided that break time should preventively counteract not only bad posture, but also other typical health risks associated with computer screen work. Breaks as intervention type are described in Section 4.2.

In addition, users can activate a so-called meeting mode to prevent disruptions caused by reminders or breaks. Given that meetings are part of the working time, breaks that would have been scheduled during the meeting are displayed afterwards.

4.1 Reminders

Four different reminders were implemented: *blink*, *dynamic sitting*, *distance to screen*, and *motivation*. Reminders should not interrupt the workflow. Therefore, they contain only a headline and a descriptive sentence. They appear as a pop-up notification via the operating system. In addition, the reminders contain different icons so that the messages have a recognition effect and can thus be grasped more quickly.

The four reminders displayed by the system are shown with their triggers in Table 1. The *blink reminder* is intended to support the user in maintaining a blink frequency high enough to prevent the rupture of the tear film (Schmidt, 2008), even during concentration phases on the screen. The threshold of 12 blinks per minute was chosen because the normal spontaneous blink rate is between 12 and 15 blinks per minute (Doughty, 2001).

The *dynamic sitting reminder* was implemented, based on recommendations by (Mohokum & Dördelmann, 2018) to change the sitting position frequently. For this purpose, the distance of the posture points recorded by the CareCam is used. If the distance changes by 12 pixels, this is classified as a movement. The reminder is triggered if there is no

Table 1: Implemented reminders.

System Message	*Trigger*
Blink Reminder Remind yourself to blink enough, please.	blink rate < 12 blinks per minute
Dynamic Sitting Reminder Please change your posture.	no major movement within 2 minutes
Distance Reminder Your eyes are too close to the screen.	distance < 50 cm for 30 seconds
Motivation Reminder "Quality means doing it right when no one is looking." -Henry Ford	predominantly negative facial expression within one minute

movement after 300 captured images, which corresponds to approx. two minutes.

The *distance to screen reminder* helps keeping the right distance between the monitor and the eye. This is important as eye fatigue should be avoided (Mohokum & Dördelmann, 2018) and maintaining distance affects the posture, too. Depending on the activity, the distance between the eyes and the screen is determined based on the screen's size or the characters' height. The minimum suggested distance (for small 13-inch screens) of 50 cm has been specified for the distance reminder for simplicity. Finally, facial expressions may, e.g., contain clues to stress and anxiety (Giannakakis et al., 2017).

An attempt to counteract negative emotions is implemented through the *motivation reminder*. Once per second, the emotional state is stored. To exclude short-term reactions that do not have a larger effect, we chose a time window of one minute as decisive. After one minute, when 60 emotion states have been stored, the predominant emotion in terms of frequency is determined. If the facial expression is predominantly characterized by a negative emotion (sadness or fear), the reminder is triggered. In this process, different motivational messages are displayed randomly. Overall, to prevent a reminder from appearing too frequently and thus interrupting and disturbing the user during work, each triggered event is stored in a buffer. Only after five minutes have passed, this reminder can lead to a notification again by the trigger.

4.2 Breaks

Breaks are suggested regularly based on the health data recorded by CareCam. Breaks are divided into active breaks that are guided by the system and free breaks. Active breaks are filled with exercises, while the user can spend free breaks individually. Exercises do not just focus on muscle contraction as implemented in (Herrera et al., 2021). In contrast, CareCam can provide breaks with versatile exercise contents that, beyond posture, address other topics such as breathing exercises or mental aspects (e.g., mindfulness). According to (Mohokum & Dördelmann, 2018), the rule of thumb is to take a screen break of five to ten minutes every hour. Therefore, it was decided to include as intervention five-minute breaks time after 55 minutes of screen time. As it can be recognized whether the user is in front of the camera at the computer workstation, individual breaks can be taken into account. Times that the user is absent from the screen do not count into the 55 minutes. The user is informed via system notifications when an active or free break is upcoming, as can be seen in Figure 2.

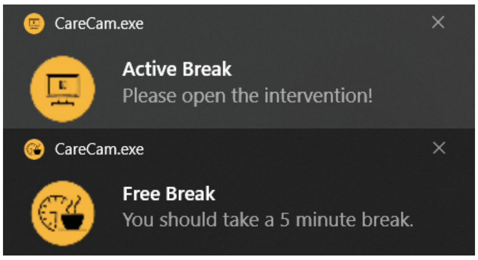

Figure 2: Break notifications.

Exercise interventions can be divided into three groups: “eyes”, “posture”, and “mindfulness”. This division was made because visual problems, musculoskeletal problems, and stress are among the most common computer-related health problems (Mary & Munipriya, 2011). To decide which intervention group has priority during the break, the reminders are counted during the 55-minute work period and the highest group counter is prioritized for the suggested exercise. The categorization can be seen in Table 2.

As blinking frequency and maintaining distance from the screen both influence the health of the “eyes”, the counter for this intervention group is increased by one each time one of these reminders is triggered. Given that a short distance to the screen can cause the head to bend forward and thus promote the development of a “turtle neck”, the counter for the

Table 2: Exercises suggested for active breaks.

Group	*Exercises in the group*	*Events that increase the group counter*
Eyes	Relaxation of the eyes, change of directions of gaze	Display of blink reminder, display of distance reminder
Posture	Stretching and loosening exercises, standing breaks	Display of dynamic sitting reminder, display of distance reminder
Mindfulness	Deep breathing	Display of motivation reminder, every two work intervals

"posture" intervention group is also increased by one. Additionally, the reminders to sit dynamically increase the counter for this intervention group by one, as static muscle activity can lead to tension. The "mindfulness" intervention group is increased by one by the motivation reminder. Furthermore, the counter is increased by one every two work phases of 55 minutes each. This was decided because working long hours can be a factor for stress that could be mitigated with mindfulness exercises, which get a higher priority with the increased counter. The typical appearance of an exercise is presented in Figure 3. The exercise contains an image illustrating what to do together with a short textual description. Furthermore, a progress bar depending on time is shown.

All exercises are meant to be performed within the scheduled five-minute break. However, the performance of the exercises does not completely fill in five minutes. This ensures that the break time does not have to be exceeded. In that way, the user has enough time to read through the exercise and can furthermore use the remaining break individually, e.g., to get a glass of water, to exchange ideas with colleagues or simply to have an additional mental break without a task. After an intervention group has been triggered, the counter for this group is reset. The counters for the other groups remain the same in order to balance the occurrence of intervention groups. In addition, with this implementation a group – and thus a potential health issue – can be addressed again if it stands out. If the software is restarted, e.g., on the next workday, the counters for all groups are back to zero.

Free breaks can be used however the user wants to. A change of work activity is also possible. This notification occurs when all health parameters are uneventful: i.e., when no reminder has been triggered, or the counters for all intervention groups are zero.

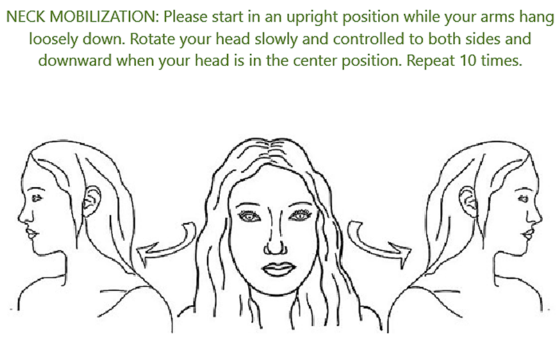

Figure 3: Exemplary Exercise.

5 USER-PERCEPTION OF THE INTERVENTION SYSTEM

The emphasis of this work is to examine how real-world users perceive different types of camera-based health interventions. Therefore, we conducted a pilot study providing the running system. The approach of our case study is described in Section 5.1. Through the test phase with subsequent interviews, information was collected on the perception and design of the health interventions as well as on further functional wishes and aspects, which are presented in Section 5.2.

5.1 Case Study Approach

The study was planned as an initial exploration with a convenience sample. Five research assistants and two students registered for the study and were provided with the software to test it during one work week. Our case criterion is knowledge-intensive work at the computer workstation. The participants come from the field of computer science, and thus, a certain IT affinity can be assumed that might be helpful in a first software test. The average age of the participants was 31 years. Five women and two men participated. The software was tested in the everyday work environment by the participants. In advance, the participants received instructions via a PDF file so that they were able to install the software on their preferred device. They had the control to start and stop the software, and thus, they had control over the webcam. Furthermore, measurements and triggered interventions were only stored locally. After the test phase, semi-structured interviews were conducted in German. For this article, the participants' statements were thus translated. The interview answers were evaluated with the help of a inductive categorization method similar to (Mayring & Fenzl, 2014). The categories are oriented towards the following objectives and topics of the interview guide:

- Perception of the reminders and breaks
- Functionality of the meeting mode
- Acceptance of the software
- Desired features

5.2 Findings

5.2.1 Perception of Reminders

Regarding the **general perception**, the *icons were mainly perceived as positive and helpful* for faster recognition of the reminders. It was thus "not such a big distraction". The different colors of the icons were emphasized by three people as a recognizable feature. After getting used to the reminders, they "strongly associated the message with the color." One participant was generally less aware of the reminders due to the layout of her workstation, through which these did not appear on her main screen. Thus, she felt the program should optimally offer the possibility to set the screen on which the reminder is displayed. Two other test persons also described that due to the structure of their workstation in home office, they only saw the reminders "out of the corner of their eye" and thus mostly overlooked or "barely noticed" them.

The **frequency of the reminders** *was perceived very differently* depending on the reminder type. Apparently, the time of day when work is done, and the duration of work can also influence the perception of the frequency. One participant described the frequency as being "just right for the normal work situation and normal work hours." However, when exhaustion from work becomes noticeable, "more indulgent reminders" were longed for by "increasing the time interval a bit." Due to habituation, one person's reminders "faded into the background". Nevertheless, there was also the case that the reminders appeared very frequently at the beginning and became less frequent due to compliance. The effectiveness of the reminders was, therefore, different for the participants.

The **blink reminder** was triggered very frequently for most participants. Three participants received the blink reminder very frequently, "all the time", rating the blink count as inaccurate in consequence. On the contrary, two other participants considered the blink reminder to be "very helpful", with one person also receiving the reminder very frequently. In this case, the blink count was not doubted. The other person rated the blink reminder as "totally good" because the usefulness behind it was familiar. Therefore, for this person, "it actually did not matter whether it really came at the right moment, whether it was plausible, but it was just good to be nudged again." The remaining two participants could not receive blink reminders or did not perceive them. It was also suggested that the unit of blinks per minute would be useful to support self-reflection.

The frequency of the **dynamic sitting reminder** was experienced very individually: the descriptions ranged from "rather seldom", "regularly" to "now and then a bit much". Four of the six participants who had noticed the reminder considered this reminder to be useful and helpful. However, the fit of the trigger timing was experienced differently. For two participants, the reminder was not specific enough, as it was not described in which way the position should be changed. For this, advanced posture recognition was desired, for example, to be able to display the tip "Lean back" in case of a forward-leaning posture.

The **distance reminder** was rarely displayed for the most part. Three participants did not receive this reminder or did not notice it. One person found the reminder to be good and suitable. Another participant had problems keeping the distance "since my desk is not particularly large and that automatically makes me sit closer." This means that the distance adjustment could not be made, which resulted in the reminder not leading to any change in behavior. In addition, the idea was expressed once to even combine distance detection with posture detection so that the forward head posture, "this slight hump that you make when you bend over", is additionally recognized. This participant described the reminder as "the way it is now, not quite so reasonable".

The **motivation reminder** was hardly triggered in the test phase. Two participants turned off this feature, because of technical issues or because emotions were mostly neutral. Of the other people, only one person received the motivation reminder once and described it as follows: "Well, I thought it was funny, it was kind of cool that it was a quote." The motivation reminder was explicitly wished for more once: "to loosen up quite nice, quite interesting." However, due to quality issues with the emotion recognition and/or often neutral emotions, the trigger for motivation reminders should be rethought for future systems.

5.2.2 Perceptions of Breaks

The **general perception** of breaks and break exercises *has been positive,* and participants expressed interest in the exercises. However, two participants could not perform active breaks, because of technical issues or because they were not noticed or were probably not displayed, caused by forgetting to deactivate the meeting mode.

Regarding **exercise content**, in several interviews, the relevance and *wish for varied exercises* had been highlighted "to keep it a bit exciting". Two test persons emphasized that it was good "if you did not know the exercises yet", they received "really always nicely different" exercises, a sort of "surprise effect". Two test persons, who in contrast also received a repeated exercise, perceived this negatively and did not do the exercise that appeared twice. One person justified this with the type of exercise because she found it "boring" and rated eye exercises on the screen as rather unsuitable and mentioned that alternatively, it would be more helpful to "stand up, look out of the window, look into the distance". Eye exercises on the screen would have to be "rather something entertaining, if necessary at all", such as colorful searching images. For the other person, the frequency of the interventions was stated as a reason for not doing the repeated exercise.

However, the **frequency of breaks** was rated differently by the test persons, with *most of them finding the frequency "exactly right" and "sufficient"*. A break once an hour thus proved to be suitable for the most part. Only one person emphasized that there were too many active breaks in general. There is a preference here for less active breaks, but still receiving a break reminder every hour. In this short test phase, only one participant knowingly received a free break. It would be conceivable, for example, to alternate between a free break and an active break to allow a little more freedom for the arrangement of the break. In addition, more acute interventions could be suggested independently of the time interval if certain values are strongly abnormal, as requested by one participant.

The **length of the exercises** has received *different reviews*. Generally, a break time of five minutes was set, but the exercises did not have to fill the time completely. Not all participant recognized the corresponding notice in the tool instructions. One user described that the interventions "went on for what felt like an eternity", and half the time would have been enough. For more advanced interventions, the progress bar should be tailored for the different exercises and, if necessary, display the remaining break time after the exercise is completed to avoid confusion. Other participants described the exercises as "all very short" or easily integrable into their daily work routine, as they were "always just like five minutes [to take] a quick break." Another participant also expressed an idea that it would be ideal if, during exercise, the software could "detect and then count down" when an exercise was being performed in front of the camera. This could make "the system feel more alive", and it would have an "interaction factor." A type of reward after successful completion of the exercise would have an additional motivating effect.

In four interviews, it became apparent that more **information about the reason** and *goal of a particular intervention being suggested is a meaningful motivation component*. One user points out that "one or two sentences" in a "pop-up would be absolutely enough". Furthermore, it was emphasized that the *fast and easy comprehensibility of the exercise*, "in a few seconds", is important. The exercise must be "unambiguous in its description" and "described in an understandable way". The "ease of execution is [...] a major criterion" so that a user can "easily integrate the exercise into the daily work routine." The length of the exercise is also an important factor. Here, too, a balance must be found so that the exercises "have an effect" but are "not too long". The current exercises were mostly rated as "well [...] applicable" and "sufficient".

The **preferred format for the exercises** is a *video or animation* for six of the seven users. The other participant prefers "simply designed things". She perceived the mindfulness exercise "as totally helpful", which includes a very simple animation with little text. In general, less text description is favored. The abstraction of the current intervention images could be kept for videos or animations: One test person found it "very appealing […] to work with abstract figures". Another test person emphasized: "Well, it does not have to be a human being demonstrating it to me." Apart from that, the suggestion to underlay "mindfulness exercises [...] with music" was expressed by a user.

5.2.3 Usage of the Meeting Mode

Two of the seven users tried the meeting mode. Once, the meeting mode was tried at the beginning, but the software led to difficulties. This is due to the exclusive access of CareCam to the camera so that no other program could access the camera, while access is also needed for meetings. As a result, it was completely turned off for meetings by the participant. As the other test person had complications with the performance of the software, he decided to switch off CareCam for meetings right away. The meeting mode has been partially forgotten, causing inconvenience to one user: An intervention occurred in the middle of an online presentation because the meeting mode was not activated. Another user "did not re-check every time" to see if meeting mode had been deactivated again. As a result, reminders and breaks were also unknowingly suppressed during other work activities.

At one point, it was emphasized that in contrast to breaks, the reminders would be interesting and "even more useful than [...] under stress", especially during video conferences. The reminders "are not so intrusive that they distract you from a conversation."

5.2.4 Software Acceptance

A general interest in the functions of the CareCam is present in six out of seven participants. Five of them could imagine using the software permanently during high screen time. Only one participant would rather not use the software in everyday working life, because the person has the impression that it is "quickly in the background. That it's just an app that runs on the side [...]". Another person is unsure because, on the one hand, the CareCam gives her the feeling of being "watched all the time", as "the camera is running all the time". On the other hand, the software is perceived as "totally exciting" and "informative" because it offers many possibilities and draws attention to health data that are otherwise overlooked. Two of the six interested individuals did not mention any concerns with using the software. Using it as a local tool gave one participant a feeling of security that eliminated concerns. Concerns arise mainly on data privacy because it is "something quite personal if you are constantly being filmed in front of your screen".

For data processing, "absolute transparency and a guarantee that the data will not go anywhere" is demanded for using the CareCam. It could be helped by "an agreement" assuring that no data is stored or distributed. Besides, not every user seems interested in all of CareCam's features. Personalization options for the software could additionally increase acceptance.

5.2.5 Desired Features

The following lists of features were gathered from the various interviews and could increase user satisfaction as enhancements to our existing system. A grouped overview is provided in Figure 4. Participants were asked in the interviews what further types of and features for **reminders** they would desire:

Regular breathing: Two participants could imagine a reminder that controls the regularity of breathing and reminds them to focus on breathing when it is irregular, or breathing interruptions occur.

Advanced posture detection: Posture improvement is a focus of several users. The current reminder about the sitting position only analyzes whether the user moves regularly. It lacks a more precise assessment of the sitting position to be able to issue more accurate reminders for changing the position. Furthermore, it is possible to evaluate the sitting position based on the quality. In case of an unfavorable posture, another reminder could intervene. Three participants have considered using an additional camera placed on the side to perform more advanced posture analyses. These analyses could be used to better estimate the sitting position, e.g., detecting a forward-leaning posture and send more precise reminders.

Display working time: One user has requested an intermediate output of the working time spent at the screen workstation.

Individually configurable reminders: Different users may have individual habits they want to prevent. Simple, individually configurable reminders could provide a solution. Time-triggered reminders would be an option for realizing this. For example, the system could send reminders not relevant to every user, e.g., for drinking enough water. In addition, it should be possible to deactivate or adjust the triggers of the other reminders. If a reminder is perceived as negative or annoying, this may also affect the perception of the other reminders. Next, it should be possible to configure the time interval and, thus, the frequency between the reminders. For example, different intervals at different times of the day or after long working hours can be required.

The participants also expressed further wishes and ideas for **active breaks**:

Snooze function: It may happen that a break is not suitable at the moment. A kind of snooze button could allow the user to "finish what he is working on" so that one's thought process is not interrupted. However, a snooze function should be integrated with care to prevent the user from always skipping the interventions. One way of implementing this could be to allow the snooze function to be used only once for each break, e.g., the user could get "10 minutes, but then" the break should be taken.

User preference: The user should be allowed to define his or her priorities. A kind of "user profile" so that the program can "provide even more individualized tips" to improve the achievement of personal goals and can more frequently suggest "exercises or interventions that match these". The specification of priorities could also be done after a "kind of initial phase" in which different exercises are shown. Rating options could additionally be used so that the system can learn what kind of exercises are liked by the user. The frequency of the exercises and the preferred length of the breaks should also be specified as setting options, e.g., to opt for more frequent shorter breaks.

Interactivity: The progress bar for breaks should be tailored for the different exercises. Automatic control of exercise performance could even make time-dependent bars obsolete and make the system feel more interactive. After completing an exercise, a reward system could increase motivation.

For motivation and a better understanding of the software, the participants expressed the necessity to include **extra information**. Desired features in that direction are:

Setup assistant: The first start of the software could be supported by a setup assistant. Among other things, the correct positioning of the camera and the various setting options should be shown. In general, an explanation that introduces the various parameters of the CareCam would increase understanding of the software. Detailed, general explanations of health aspects are also desirable, e.g., the optimal posture at the workplace or the correct distance to the screen. Hints as to why certain things should be maintained could contribute to increasing motivation.

Info button: The explanations and information presented by the setup assistant should be "always accessible". At times in between, "not the full explanation program" will be appropriate. Using info buttons could maintain a manageable software layout while providing additional information. This allows the information to be re-read as needed, and the user is not "overwhelmed with information". In this way, further information about the reasons a reminder or intervention appears and additional "more specific tips" could be integrated. Also, information about data privacy should be available at all times.

Concerning the **noticeability** of CareCam interventions, the following features were mentioned:

Sound support: A customized sound would be useful to differentiate CareCam notifications from other notifications. Overlooking reminders and pauses could probably be reduced with this.

Display setting options: It should be possible to select the screen on which the notifications are displayed, as well as the duration of the display to further reduce overlooking.

Meeting mode: Enabling or disabling the meeting mode had been forgotten in some cases. Although not explicitly stated by the user, automatic detection of whether the user is currently participating in a meeting could solve this problem. Finally, activation of reminders separate from breaks should be possible, e.g., to still receive reminders during meetings.

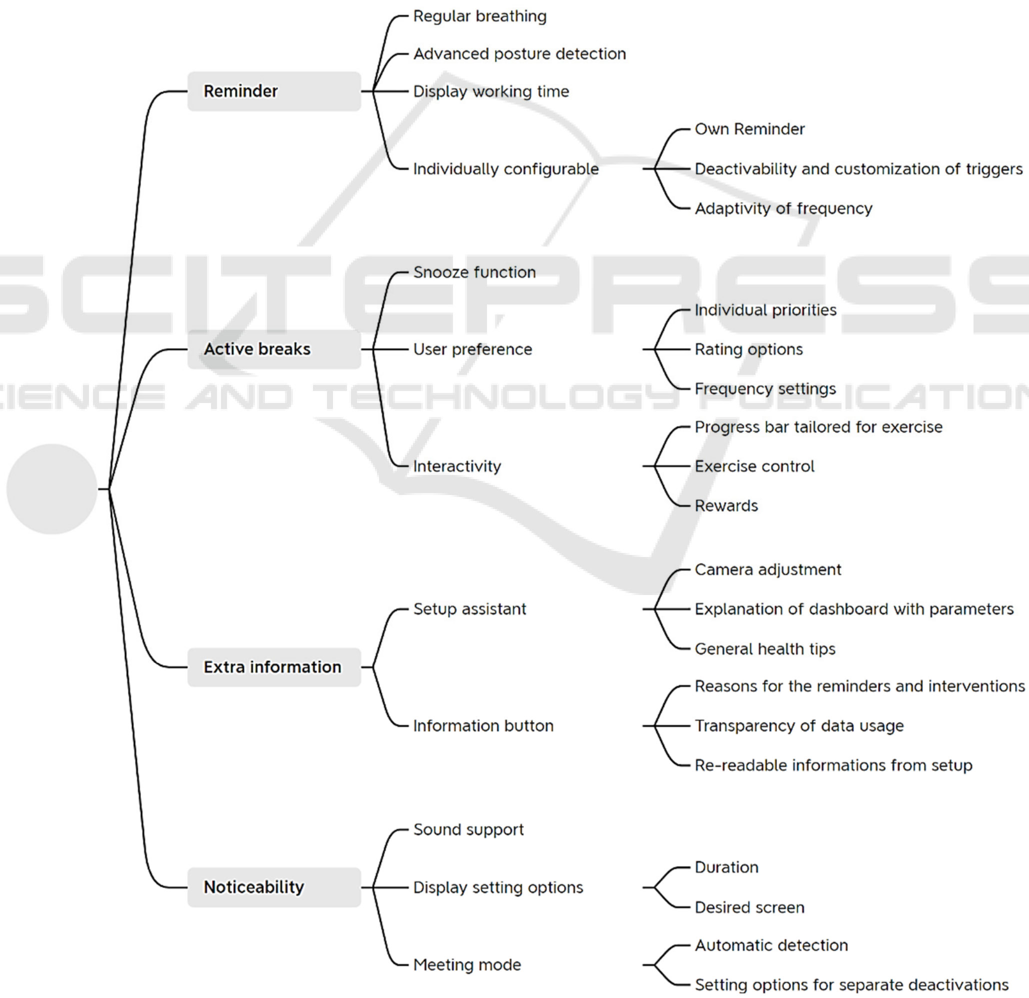

Figure 4: Overview of further features.

6 DISCUSSION, LIMITATIONS AND FUTURE WORK

6.1 Discussion of the Findings

To summarize our research, we conducted a first real-world user test of a prototype system for webcam-based health-promoting interventions derived from health literature. The key characteristic of the system is that it seeks to nudge the user towards healthy working habits via interventions in the form of reminders and (active) breaks. Both are initiated proactively by the system and are sensitive to the users' current work behaviors and emotional states. This is made possible by permanently running computerized analyses of the user in front of the workstation leveraging advanced image processing capabilities for automated recognition of blink, posture, distance, and emotion. This recognition of the current users' state is complemented by a system of counters. According to the counters, it is periodically decided which is the next best health promoting intervention for the individual user.

Since the user perspective of such interventions is a still an under-researched topic, we emphasize the empirical analysis of the users' perceptions of our prototype system in the work at hand. To do so, we conducted a first case study in which seven participants used the system for approx. one week in their real-world working environment during their daily work. Subsequently, we conducted and analyzed interviews which has led to important insights about the functioning, usefulness and ease of use, and overall acceptance of such a system. Moreover, we did also identify improvement potentials for the prototype system. In the following, we briefly discuss our main results.

In general, ***reminders*** *were perceived as useful*, whereby clearly dynamic sitting and blink reminders received more positive comments than distance and motivation reminders. This can be explained largely by implementation deficiencies of our system, where distance reminders and motivational messages did not work accurately for all users and did not show up for all of them. The general positive perception of our reminders is consistent with reminders being the number one feature that is implemented in 72% of the behavior change systems according to a recent study (Villalobos-Zúñiga & Cherubini, 2020). Additionally, since the reminders of our system depend on the observed current user behavior and emotional state, they thus adapt to the user and in this sense are personalized. This may contribute to and explain the overall positive feedback on the reminders and would be in line with empirical findings that attest personalized reminders a much higher acceptance than uniform reminders (Alhasani & Orji, 2022). Further, the *effectiveness of reminders varied across different subjects* since some subjects observed a decrease of reminders due to their beginning compliance, i.e., habit change, while others did not notice that. The person-specific effectiveness is also emphasized by large empirical studies in the field of persuasive systems that call for personalization as a major design principle to raise effectiveness (Yfantidou et al., 2022). Future versions of our prototype system could adapt even more to individual user preferences, e.g., by providing more fine-grained control over reminder settings. Also, situation awareness could be increased by automatically detecting meeting situations based on computer usage or access to the users' calendar.

Beyond personalization, the general motivation of users is emphasized as a driver for system use in the context of self-tracking (Feng et al., 2021). In regard to deeper underlying motives, also coined as "generative mechanisms", it is known that amongst others, the longing for self-improvement, confirmation and self-knowledge (Rieder et al., 2021) drives system use. It can be assumed that all test persons in our sample implicitly were driven by such motives, so results might differ for other audiences.

Further, ***breaks*** *were appreciated, although preferences for breaks differed considerably across users*. For some users, having a five-minute break per hour was just right, while others preferred longer working periods or shorter breaks. Once more, this calls for advanced personalization, which is in line with literature on persuasive systems (Yfantidou et al., 2022). Regarding the exercises during an active break, there seems to be a consensus that *exercises should be "a bit exciting", i.e., not repetitive or boring, and that video or abstract illustrations are preferred over textual descriptions*. The importance of providing varied content to users to avoid boredom is well-known in persuasive systems literature (e.g., see (Wiese et al., 2020)).

Regarding ***meeting mode****, our main insight is that users do not switch off reminders completely* but would prefer to still receive reminders that can be followed with low cognitive effort, such as dynamic sitting and blink reminders.

Concerning the **overall acceptance of the system**, *the CareCam system was perceived positively as an innovative new tool for more health-aware work habits. Six out of seven test users had a generally positive attitude towards the system after they used it, of which five expressed interest in continued usage*. A possible explanation for this might be our convenience sampling strategy leading to test users with rather high interest and motivation. However, since the system directly addresses health problems such as back pain via reminders and exercises being highly plausible countermeasures, another explanation for acceptance could be deduced from the Health Belief Model (HBM). In a nutshell, the model posits that acceptance emerges when serious health issues are perceived and countermeasures are believed to be effective in mitigating them. This model has also has been integrated with the rather "traditional" TAM model for technology acceptance (Ahadzadeh et al., 2015) as well as with the more recent UTAUT model (Alpar & Driebe, 2021) showing the significance of the HBM in terms of acceptance. This amalgamation of models could provide a valuable theoretical framework for future research on acceptance. Further, a relevant issue concerning acceptance was data privacy. Although all data was stored locally and nothing was transferred, some users expressed concerns about potential privacy issues. Clearly, this calls for further research on how to mitigate potential trust and privacy issues which could be informed by the Privacy Calculus as theoretical lens to study data sharing willingness for self-tracking data (Dincelli & Zhou, 2017), also in the work context (Toftgård, 2022). However, acceptance will considerably depend largely on the usage scenario. For example, if the system is provided by a trusted third party such as a public health insurance company, acceptance might differ in contrast to if the employer provides it.

For further development, *the largest group of* ***improvement suggestions****, i.e., more than one-third, relate to advanced* ***personalization options*** (cf. Fig. 4). This again is in line with the extant recent literature in persuasive systems that emphasize the personalization as a basic requirement (e.g. (Cho et al., 2022; Coşkun & Karahanoğlu, 2022; Yfantidou et al., 2022)). Similarly, it is reflected by the research stream on self-tracking technology abandon behavior that, amongst other factors, identify misalignment between personal goals and the capabilities of technology as decisive for discontinuance (Lazar et al., 2015). Personalization also offers the possibility to find a better balance between health goals and the situational requirements during work. For example, in a nightly work session shortly before a deadline, a user might want to receive less active break reminders or even switch them off, whereas, on the following day, they are highly appreciated again. However, increased self-responsibility comes at the risk that users apply settings that undermine the effectiveness of the self-tracking tools. To mitigate this, default settings grounded in health research in conjunction with warnings when the user applies extreme settings could be used. Finally, health is an individual topic that affects everyone, but different aspects can be the focus. With advanced personalization options, the self-responsibility of users is emphasized. Configuring one's own personal intervention system could increase the willingness to execute exercises and comply with self-adjusted interventions (i.e., be consistent with and stick to one's own goals). This argument is closely connected to research on how technology becomes a device for augmenting one's willpower (volition) that is required to actually execute actions corresponding to one's motives (Hamari et al., 2014; Schroeder et al., 2021). The distinction between motivation and volition is also an integral part of the Health Action Process Approach (HAPA) (R. Schwarzer, 1992). In this direction, the CareCam prototype supports both, the motivational phase where the user applies personal settings based on his or her motivation, and the volitional phase, where the user is nudged to execute the own-desired behavior. Beyond personalization, some improvement suggestions of test users related to the types of reminders, the contents and interaction features of active break exercises, the information that the system provides, and the noticeability of reminders (cf. Fig. 4).

6.2 Limitations of Our Research

The most obvious limitation of our first and preliminary evaluation with test users is the rather small sample size. Nevertheless, with real users in a real environment doing their ordinary work our evaluation qualifies as an early *ex-post naturalistic evaluation* according to the evaluation strategy selection framework from Pres-Heje and Baskerville (2012) (Venable et al., 2012) or an EVAL3 (proof of applicability) or even EVAL4 (proof of usefulness) according to the framework of (Sonnenberg & vom Brocke, 2012). However, we still consider our evaluation as early and preliminary, i.e., as a *formative evaluation*, where rich user feedback is collected to further improve the artifact. Future, more *summative* evaluations with a larger sample size allowing for quantitative analysis with more standardized question items, e.g., from the Unified Theory of Acceptance and Use of Technology (UTAUT 2) model (Venkatesh et al., 2012), are still do be done. However, early evaluations in the context of new and innovative artifacts could be considered analogous to the preclinical phase of developing a new medicine – the later effect in the living organism cannot be determined at the stage of development of this new substance. Rather, it has to be tested later on in clinical studies (Karagiannis, 2010). Another limitation is the period of our evaluation being one week. In future research, it would be interesting to run a longitudinal study to analyze more long-term A, B, C outcomes (Attitudes, Behaviors, Compliance outcomes (Oinas-Kukkonen, 2010) of the system and study possible habituation effects.

6.3 Future Work and Research Possibilities

The interviews have shown which developments would improve the user perception of the system and thus ensure the success of the health interventions.

The different perceptions and wishes of the participants highlighted the need for a higher level of personalization of the software. Not every user is interested in all features provided by CareCam. The intention to change one's behavior is a central component of the effectiveness of health interventions. A certain degree of self-responsibility through personalization options enables users to define goals for themselves that they really want to reach. The option to adjust reminders or create own reminders could realize this individual goal setting.

Moreover, the categories of the exercises should also be prioritized by each specific user. For example, some users may be interested in improving posture but do not care about mindfulness. A prioritization could be inquired at the beginning, which should be editable at any time. In addition, after each exercise, the system could request a basic rating of how the user liked the exercise, allowing the system to adapt the predefined user profiles as necessary.

The triggers of the current reminders can be further refined. Future reminders or interventions, especially in the area of stress and well-being, could benefit from including measures of pulse rate and pulse rate variability.

A calibration phase that captures various factors, such as age, could provide the opportunity to include these more complex measurements.

Since the motivational messages were only noticed once, this trigger should also be changed. The reason for this is the dependence on emotion recognition. Here, further research is needed to examine whether the intensity of emotions during office work is high enough. During our test, some users described that emotion recognition mostly displayed a neutral state. Besides emotion recognition, the measurements should also be improved regarding blink detection.

Generally, it is crucial to prevent the reminders and pauses from being overlooked. The display of the reminders should be given setting options for this as well as an individual sound and a design that distinguishes itself even more from other messages.

7 CONCLUSION

Many employees spend large parts of their working time sitting in front of a computer workstation, potentially leading to serious health problems in the long run. To counteract this, a few monitoring and intervention systems have been developed. However, up to now, the user perspective is still under-researched. Hence, we address this gap in presenting results from a first investigation how users perceive such an intervention system. The system is based on CareCam and generates health-promoting interventions for blink frequency, body posture, screen proximity and emotion-based messages. Several subjects used the system in a real-world case study during their ordinary daily work for one week. We then gathered rich qualitative feedback based on interviews from which we distilled insights on how users perceive such a system. From a high-level perspective, key results are:

(1) *Reminders are an effective instrument to raise awareness for unhealthy work behaviors and promote healthy ones.* All test persons welcomed the reminders; surprisingly, no one felt interrupted or disturbed by them.

(2) *Active breaks with versatile content are welcomed, but customization is needed.* All users did express their interest in exercises that must be easy to understand and perform. The format should include minimal text and preferably show a video or animation. To further increase awareness and motivation, more explanations and information in the software are needed and have been asked for by most participants. Further, customization regarding frequency and duration is needed.

(3) *Personalization options are of vital importance.* The largest parts of improvement suggestions and feature requests are related to personalization. The possibility of fine-tuning the system can increase the effectiveness of reminders and compliance behaviors for exercises. It moreover emphasizes the self-responsibility of the user.

Our final conclusion is that the ultimate quest in designing an effective health-promoting intervention system seems to be finding a balance between effectiveness and user satisfaction. The user must perceive the health interventions as comfortable and applicable as possible to be willing to implement them on a regular basis. At the same time, interventions must be effective regarding health-related outcomes.

All in all, our work contributes to the field of health-promoting intervention systems for computer-based work. Our preliminary empirical observations and findings could be a starting point to inform the design of future intervention systems.

REFERENCES

Ahadzadeh, A. S., Pahlevan Sharif, S., Ong, F. S., & Khong, K. W. (2015). Integrating health belief model and technology acceptance model: An investigation of health-related internet use. In *J Med Internet Res. 2015* Feb 19;17(2), e45.

Alhasani, M., & Orji, R. (2022). SortOut: Persuasive Stress Management Mobile Application for Higher Education Students. In N. Baghaei, J. Vassileva, R. Ali, & K. Oyibo (Eds.), *PERSUASIVE 2022* (Vol. 13213, pp. 16–27). Springer.

Alpar, P., & Driebe, T. (2021). Patients' Attitudes Toward Apps for Management of a Chronic Disease. In S. Stieglitz, R. Schütte, & F. Ahlemann (Eds *Information Systems and Organisation. Innovation Through Information Systems: WI 2021.* vol. 46, pp. 22–37). Springer.

Rieder, A, Lehrer, C., Eseryel, Y., & Jung, R. (2021). The Generative Mechanisms Behind Technology-enabled Health Behavior Change. In *ECIS 2021*.

Bitkom. (2018). *Bitkom Digital Office Index 2018: Eine Studie zur Digitalisierung von Büro- und Verwaltungsprozessen in deutschen Unternehmen*.

Burkhart, S., & Hanser, F. (2018). Einfluss globaler Megatrends auf das digitale Betriebliche Gesundheitsmanagement. In D. Matusiewicz & L. Kaiser (Eds.), *Digitales Betriebliches Gesundheitsmanagement: Theorie und Praxis* (pp. 37–55). Springer.

C. Chen, T. Määttä, Kevin Bing-Yung Wong, & H. Aghajan (2012). A collaborative framework for ergonomic feedback using smart cameras. In *ICDSC 2012*.

Cho, J., Xu, T., Zimmermann-Niefield, A., & Voida, S. (2022). Reflection in Theory and Reflection in Practice: An Exploration of the Gaps in Reflection Support among Personal Informatics Apps. In S. Barbosa, C. Lampe, C. Appert, D. A. Shamma, S. Drucker, J. Williamson, K. Yatani (Eds.), *Proc. CHI 2022* (pp. 1–23).

Coşkun, A., & Karahanoğlu, A. (2022). Data Sensemaking in Self-Tracking: Towards a New Generation of Self-Tracking Tools. *International Journal of Human–Computer Interaction*, 1–22.

Dincelli, E., & Zhou, X. (2017). Examining self-disclosure on wearable devices: The roles of benefit structure and privacy calculus. In *AMCIS 2017 Proc*.

Doughty, M. J. (2001). Consideration of three types of spontaneous eyeblink activity in normal humans: During reading and video display terminal use, in primary gaze, and while in conversation. In *Optom Vis Sci. 2001 Oct; 78*(10), 712–725.

Feng, S., Mäntymäki, M., Dhir, A., & Salmela, H. (2021). How Self-tracking and the Quantified Self Promote Health and Well-being: Systematic Review. In *J Med Internet Res. 2021* 23(9), e25171.

Fichter, K., Clausen, J., & Hintemann, R. (2012). Roadmap: »Resource-efficient workplace computer solutions 2020«: Development of a lead market for green office computing. *BMU, Federal Environment Agency & BITKOM, Berlin, Dessau, Roßlau, Leitfaden.*

Giannakakis, G., Pediaditis, M., Manousos, D., Kazantzaki, E., Chiarugi, F., Simos, P. G., Marias, K., & Tsiknakis, M. (2017). Stress and anxiety detection using facial cues from videos. In *Biomedical Signal Processing and Control*, *31*, 89–101.

Hamari, J., Koivisto, J., & Pakkanen, T. (2014). Do Persuasive Technologies Persuade? - A Review of Empirical Studies. In *PERSUASIVE 2014*, (vol. 8462, pp. 118–136). Springer.

Herrera, F., Niño, R., Montenegro-Marín, C. E., Gaona-García, P. A., Mendívil, I. S. M. de, & Crespo, R. G. (2021). Computational method for monitoring pauses exercises in office workers through a vision model. In *J Ambient Intell Human Comput 12*, 3389–3397.

Karagiannis, D. (2010). Welche Rolle kann bzw. soll die IT bei der Umsetzung und Unterstützung gestaltungsorientierter WI-Forschung spielen? In H. Österle (Ed.), In *Gestaltungsorientierte Wirtschaftsinformatik: Ein Plädoyer für Rigor und Relevanz.* Infowerk.

Kraft, D., Schmidt, A., Büttner, L., Oschinsky, F. M., Lambusch, F., van Laerhoven, K., Bieber, G., & Fellmann, M. (2022). CareCam: Towards user-tailored Interventions at the Workplace using a Webcam. In *ICPS, PETRA 2022* (pp. 494–499). ACM.

Kraft, D., van Laerhofen, K., & Bieber, G. (2021). Carecam: Concept of a new tool for Corporate Health Management. In *ACM Digital Library, The 14th PErvasive Technologies Related to Assistive Environments Conference* (pp. 585–593). ACM.

Lazar, A., Koehler, C., Tanenbaum, J., & Nguyen, D. H. (2015). Why we use and abandon smart devices. In K. Mase (Ed.), *Ubicomp 2015 Proc.* (pp. 635–646). ACM.

Maeda, N., Hirabe, Y., Arakawa, Y., & Yasumoto, K. (2016). COSMS: Unconscious stress monitoring system for office worker. In P. Lukowicz, A. Krüger, A. Bulling, Y.-K. Lim, & S. N. Patel (Eds.), *Ubicomp 2016 Proc.* (pp. 329–332). ACM.

Mary, G. M. J., & Munipriya, P. (2011). Health monitoring of IT industry people. In *ICECT 2011* (pp. 144–148). IEEE.

Mayring, P., & Fenzl, T. (2014). Qualitative Inhaltsanalyse. In N. Baur & J. Blasius (Eds.), In *Handbuch Methoden der empirischen Sozialforschung* (vol. 3, pp. 543–556). Springer.

Mohokum, M., & Dördelmann, J. (2018). Ergonomie am Arbeitsplatz mit Praxisbeispielen. In M. Mohokum & J. Dördelmann (Eds.), In *Betriebliche Gesundheitsförderung* (pp. 175–213). Springer.

Oinas-Kukkonen, H. (2010). Behavior Change Support Systems: A Research Model and Agenda. In T. Ploug, P. Hasle, H. Oinas-Kukkonen (eds) *PERSUASIVE 2010* (vol. 6137, pp. 4–14). Springer.

Paliyawan, P., Nukoolkit, C., & Mongkolnam, P. (2014, May). Prolonged sitting detection for office workers syndrome prevention using kinect. In *ECTI-CON 2014,* (pp. 1–6). IEEE.

Paliyawan, P., Nukoolkit, C., & Mongkolnam, P. (2014, October). Office workers syndrome monitoring using kinect. In *APCC2014,* (pp. 58–63). IEEE.

Park, J. H., Moon, J. H., Kim, H. J., Kong, M. H., & Oh, Y. H. (2020). Sedentary Lifestyle: Overview of Updated Evidence of Potential Health Risks. In *Korean J Dam Med 2020*, *41*(6), 365–373.

R. Schwarzer (1992). Self-efficacy in the adoption and maintenance of health behaviors: Theoretical approaches and a new model. In *R. Schwarzer (Ed.), Self-efficacy: Thought control of action,* (pp. 217-243)

Schmidt, D. (2008). *Tipps und Tricks für den Augenarzt: Problemlösungen von A bis Z. Tipps und Tricks*. Springer.

Schroeder, T., Haug, M., & Gewald, H. (2021). The difference between motivation and volition matters! A qualitative study on mobile health application adoption. In *ECIS 2021 Research Papers*, (pp.1-18).

Sonnenberg, C., & vom Brocke, J. (2012). Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research. In K. Pfeffers, M. Rothenberger, B. Kuechler (eds), *DESRIST 2012* (vol. 7286, pp. 381–397). Springer.

Taieb-Maimon, M., Cwikel, J., Shapira, B., & Orenstein, I. (2012). The effectiveness of a training method using self-modeling webcam photos for reducing mus-culoskeletal risk among office workers using comput-ers. In *Applied Ergonomics 2012*, *43*(2), 376–385.

Toftgård, V. (2022). *Employee acceptance from a privacy perspective of wearable fitness trackers at work: A qualitative study of employees in Sweden* (Dissertation).

Venable, J., Pries-Heje, J., & Baskerville, R. (2012). A Comprehensive Framework for Evaluation in Design Science Research. In *DESRIST 2012* (vol. 7286 pp. 423–438). Springer.

Venkatesh, V. Thong, J.Y., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. In *MIS Quarterly*, *36*(1), 157-178.

Vildjiounaite, E., Huotari, V., Kallio, J., Kyllönen, V., Mäkelä, S.-M., & Gimel'farb, G. (2018). Detection of Prolonged Stress in Smart Office. In K. Arai (Ed.), *SAI 2018,* (vol. 857, pp. 1253–1261). Springer.

Villalobos-Zúñiga, G., & Cherubini, M. (2020). Apps That Motivate: a Taxonomy of App Features Based on Self-Determination Theory. In *Int J Hum Comput Stud*, *140*, 102449.

Wiese, L., Pohlmeyer, A. E., & Hekkert, P. (2020). Design for Sustained Wellbeing through Positive Activities—A Multi-Stage Framework. In *Multimodal Technol. Interact. 4*(4), 71.

Yfantidou, S., Sermpezis, P., & Vakali, A. (2022). 12 Years of Self-tracking for Promoting Physical Activity from a User Diversity Perspective: Taking Stock & Thinking Ahead. In A. Bellogin, L. Boratto, O. C. Santos, L. Ardissono, & B. Knijnenburg (Eds.), *UMAP 2022* (pp. 211–221).