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BuSiNec – Studying the Effects of a Busyness Signifying Necklace in the Wild

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Figure 1. Self-adjusted wearable *BuSiNec* displaying one's subjective feeling of being busy on a three-level basis following the traffic light metaphor.

ABSTRACT
Workplace stress is a growing problem, which is often not identified by sufferers and those around them until it becomes chronic. Moreover, admitting to feel stressed is a highly private and therefore sensitive topic, particularly at work. Informed by the findings from six in-depth interviews, we designed the manually self-adjusted wearable *BuSiNec*: a *Bu*syness *Si*gnifying *Nec*klace. 18 participants wore it at their workplace and reported on their experiences and their usage behavior through a diary and in a focus group interview. Our findings indicate that *BuSiNec* supports self-reflection on stress and further stimulates valuable discussions among co-users which in turn increased mutual consideration. Participants were conscious of their their displayed busyness status towards others and used the display to encourage or discourage discussions and interruptions, or as a warning of upcoming hurry. From these findings, we derive recommendations for the integration of affective state information in wearable displays.

Author Keywords
Wearable Displays; Stress; Jewelry; Self-expression; User Studies; Low-fidelity prototyping, Necklace

INTRODUCTION
While sources of stress have been widely investigated in recent years, it has been found that an individual's feeling of 'being busy' closely relates to their stress level [8, 41, 51]. Both can be regarded as representations of inner states, which relate to the overall wellbeing of individuals, which has been widely investigated in HCI research. There exists a plethora of devices and applications targeting to support one's wellbeing, enabling people to track their activities and performance. Indeed, multiple self-tracking subcultures have emerged [35], ranging from sports focused [2, 53] to quantified-selfers [11] and mental wellness [31]. Many existing wellness applications aim to inform the user about their wellbeing on a general level, rather than reporting detailed performance measures. Such applications are mostly conceptualized for personal use, and communicate with the user through e.g. a mobile phone app user interfaces (UI) [55], a bracelet [21], a smartwatch display [23], or more abstract objects, such as MoodWings [36]. Whereas typically prior works exploring wearable display of

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wellbeing and performance data have focused on automatically generated user interfaces, e.g. based on sensor data [27], we are interested in exploring how users communicate wellbeing data when reporting it by themselves. Thus, we are led by the question of how users would interact with a mechanism to set their own wellbeing status, that is visible to others through a wearable display. Particularly, we aim to explore how users perceive the effect of displaying this information publicly, and focus on experiences during social interactions. As wearable technologies are getting more common and their design methods are continuously improving, e.g. through leveraging frameworks [15], investigating their social and design aspects is increasingly relevant to ensure the development of usable and desirable solutions [38]. The investigation of the intra- and interpersonal effects that are provoked by a self-adjusted wearable display, enabling users not only to share their inner states but at the same time to consciously reflect on them, has not been addressed by prior research. Consequently, our work provides insights for the design of wellbeing UIs that incorporate public display elements, informing on social acceptability, user experience, and issues surrounding the display manually controlled or automatically updated data.

Informed by the findings of an interview based study, we developed a prototype jewelry-type wearable display that granted its wearer the opportunity to customize its outlook. The concept was constructed from wooden materials and presented a non-technical outlook, which were perceived very positively, highlighting the importance of aesthetics and material choices. We evaluated our prototype (Figure 1) in the semi-public setting of an office workplace. Study participants wore the prototype during their normal work day, during which they encountered colleagues and other bystanders. We present the results from 18 participants communicating their perceived busyness by using *BuSiNec*.

Our salient findings show that wearing the necklace made people reflect on their stress and busyness states. Consequentially it became a tool to manage stress. The necklace facilitated discussions in the work community supporting mutual consideration, was used as a signal of availability to others, and as a cue to hint that others needed to hurry up. In summary, the presented work tackles important aspects, such as the conscious management of stress, the communication of being busy at the workplace, and informs on design considerations for affective wearable displays. Consequently, our main research contributions are,

- the presentation of a design concept for a busyness indicating wearable display, informed by in-depth interviews on one's willingness to share inner states at the workplace,
- the investigation of experiences when using a wearable display to signify one's level of busyness in a social setting, and
- five design recommendations addressing the question how to present sensitive data on inner states on a publicly visible wearable display.

BACKGROUND

As we present a self-adjusted wearable, reflecting one's personal state of being busy, we subsequently summarize relevant related work that focused on the representation of personal data. Further, we provide examples of wearable displays concepts that have been implemented and researched.

Measuring, Managing and Reporting Affective Data

In an early work on the topic, Picard and Healey [42] demonstrated the potential to measure emotional state through body worn sensors, and also noted the challenge of who should be able to view the data, e.g. a family member or a car salesman. Following this, prior work has explored the role of wearables in measuring, managing and displaying the wearer's stress stress level. Gimpel et al. investigated the potential to identify a user's stress level based on their smartphone activity, for example reporting that a high frequency of switching the device screen on/off is an indicator of raised stress [22]. Adams et al. compared stress measurement techniques that could be applied in the wild [1], whilst de Arriba et al. contributed a protocol to estimate stress levels using the sensors contained in the Microsoft Band wristband in the classroom environment [16]. In their BreatheWell concept, Wallace et al. presented an application running on a smartwatch that aids relaxation through guided deep breathing [55]. The app also allowed the user to manually input their self-perceived stress level at the beginning and end of the relaxation session. Apart from stress as one inner state, research has aimed to measure other affective states using smartwatches [18, 23, 34] or wearable sensors [46]. In a broad overview of the potential for wearables to improve the quality of life, Duval and Hashizume charted the danger and usefulness of emotional displays, reporting that sharing data with family has highest value, whist sharing with professional acquaintances has highest danger [17]. The work also reports the rejection of full Artificial Intelligence (AI) based solutions in the wearable domain, stating that people wish to maintain control of their identity. In their exploration of perceptions on affective wearables, Hassib et al. noted that, whilst generally individuals do not wish to share negative valence data about themselves, sharing such negative data can create a feeling of relief and engage support from others [26]. Focusing on wearable display of personal activity data, Colley et al. present a model highlighting the different motivational criteria of wearer visible vs. public visible data [14]. As Kinman and Jones found in a large investigation of job stress, the understanding as well as the reasons that lead to stress in the workplace are diverse [32]. Disclosure of personal sensitive feelings, such as stress level, in the workplace is not normal social practice. Thus, we utilized the less private 'feeling of being busy' as a indicator of stress level.

Wearable Displays

Wearable display have been demonstrated both for explicit information delivery and as ambient designs. The former has been demonstrated e.g in the context of sports and wellness, for sharing the running time or heartbeat [39, 48]. Colley et al. have explored different display concepts on a handbag, showing e.g information on the handbag's contents or user selected statements [13]. Subtle designs of wearable displays have been demonstrated in IdleStripes [24] and Programmable Plaid [6] shirts, which both integrate optical fibers in the garments. The IdleStripes shirt displays the duration of sitting time by gradually illuminating stripes on the chest of the shirt, motivating office workers to get up and take short walks during the day [24]. Also shape-changing clothes, such as the Scarfy self-actuated scarf [54], are examples of ambient information delivery through wearables.

Badges and neck-worn displays have also been introduced in the prior art. Early works include the Meme Tag [7] for showing memes on neck-worn LCD screen, and the Bubble Badge [19] wearable display, which encourages co-located people to discuss with the wearer. For neck-worn wearable displays, research has demonstrated concepts with a variety of functions. Jarusriboonchai et al. have presented the CueSense display, which hung from the user's neck and presented text content from the wearer's social media [28]. Ashford has presented a pendent, which visualizes the wearer's EEG using different light patterns [4]. The Distant Heart [49] by Silina and Haddadi is a computational jewelry piece, which allows sharing one's heartbeat with a remote partner using an ambient color-changing necklace.

Ambient displays and how to design them is an extensively researched topic among HCI research (see e.g. Pousman & Stasko [43]). Mankoff et al. defined ambient displays to be *abstract and aesthetic peripheral displays portraying non-critical information on the periphery of a user's attention* [37], and Stasko et al., described how ambient displays *typically communicate just one, or perhaps a few at the most, pieces of information* [52]. The importance of the aesthetics and visual appeal of the display design is also emphasized [52], which is also echoed in the emerging trend of smart jewelry [50]. Both approaches of hiding the technology entirely [3, 45], and the integration of visible technical components, typically LED lights [21, 44] have been used. In contrast, in our work we focus on experiental aspects and study the effect of a non-electronic manually-set wearable display.

SCENARIOS AND DESIGN SPACE

Based on review of the related work, we identified three approaches for the source and control of busyness information shared in the workplace. These approaches are concretized in the following three scenarios illustrating the use of a busyness display:

- **Scenario 1: Fully automated based on physiological measurements**: Marc wears a busyness display wearable that automatically detects his stress level based on physiological sensors embedded. The displays shows changes in his stress level on a short timescale and allows others to see how busy and stressed he is. By providing this information to others he expects them to react accordingly and that they would not load him with more tasks in an already stressful situation. Marc also realizes that over time, when he glances at the display himself, he gets a better understanding of when and why he is stressed.

- **Scenario 2: Automatically using activities in the digital space**: Sarah is working with Emma on a joint presentation. In her calendar a Skype call is scheduled to start in one minute. She quickly walks over to the office kitchen to grab a coffee. Her busyness display shows that she is busy based on her work pattern, her calendar, and her activities in her digital workspace. People in the kitchen say a quick hello but do not engage her in a conversation, consequently she is back in time for the call.

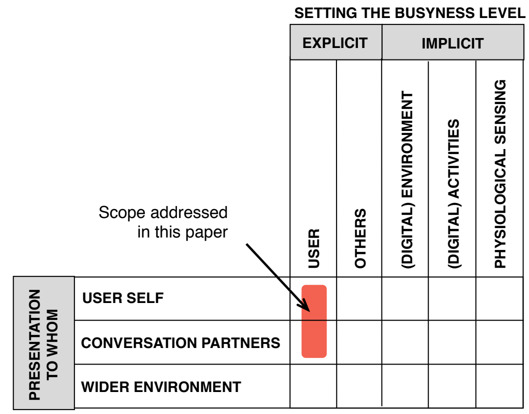


Figure 2. Design Space for wearable display of busyness level, highlighting the scope addressed in this paper.

- **Scenario 3: Manually setting the busyness state**: Ali is working towards a deadline for a customer project due later in the afternoon. Already in the morning, he set his busyness display to busy. When he moves around the workshop and the office there is little interaction with others as everyone realizes he is busy. At some point before lunch he decides he needs to de-stress himself and needs some people to chat with, so he sets his display to non-busy and goes to the common area in the office. He has a coffee and chats with colleagues. After 20 minutes he decides to go back and finish the project. As he sets the display to busy he gets on with working without disruptions.

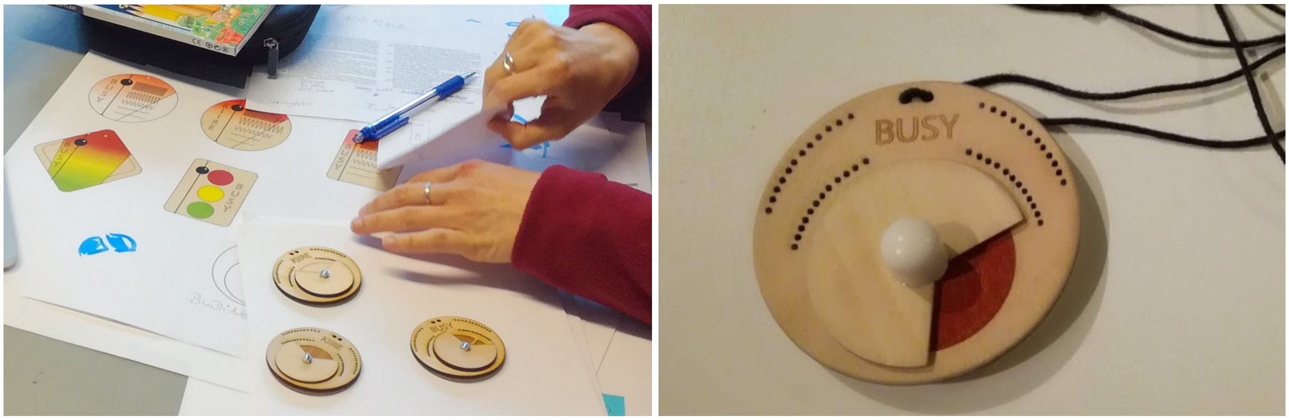
These scenarios show potential use case for a wearable busyness display with different forms and levels of user control. Rather than focusing on the technical aspects of the stress sensing, we want to understand the value for users of such technologies. Hence, we conducted a study using a low-tech prototype.

From our initial investigations we see the following major design space dimensions for a busyness display as illustrated in Figure 2:

1. Setting: Who or based on what is the busyness state set, i.e. the user, others who know the user, based on the (digital) environment, based on user activities, based on physiological sensor data.

2. Presenting: to whom is it presented, i.e., the user, the environment, others

As additional parameters we identify 1) Timing aspects of the display, i.e. how often it can change, how quickly does it react. 2) How visible is the display, e.g. a colored aura around the



(a) (b)

Figure 3. Before the final prototype was manufactured, we iterated its design (a) and particularly discussed the form factor. The *BuSiNec* in its final state can be easily rotated with a fixed knob (b).

user vs. a pin-size button on the sleeve. Visibility relates to the presentation to whom.

DESIGNING THE BUSINEC PROTOTYPE

The design process of the *BuSiNec* prototype began with interviews to collect qualitative data on people's willingness to reveal inner states. Based on the interview findings, we selected the parameters to be displayed on the prototype and gained initial directions for the design of the wearable.

Preliminary Interviews

At the beginning of the design process, semi-structured interviews were conducted to explore willingness to (a) reveal one's personal feelings in a public context, and (b) wear a prototype which displays them. The study also explored the form in which users would prefer to visualize such private feelings. Finally, participants were asked to draw how they could imagine the prototype to look like. In total, we asked 12 questions varying slightly for those interviewees which had a teaching position. One question was about what the interviewee would like to share, and two following questions explored the personal comfort while sharing this. Three questions explored suitable visualization approaches, whilst the remainder of questions inquired on the expected effects of sharing one's feelings with work colleagues and, where relevant, students.

As well as drawing tools participants were provided with precut paper basic shapes: square, circle, rectangle, rounded rectangle and triangle, as a starting point for visual ideation, particularly from those participants with a design background. As interviewees, we recruited six office workers (three females) from the University of Lapland, Finland, having a mean age of 41.2 years ($SD = 7.3$). Four of the six also teach student classes. From their educational background they were quite diverse embracing designers, computer scientists and crafting specialists. The interview length was an average of 19.35 minutes ($SD = 4.1$). The interviews were analyzed following an open coding approach, common themes were identified and a code book created, which was then used to analyze the participants' statements. We were particularly interested in what the participants wanted to share with co-workers and how they could imagine this to be visualized.

The results revealed that rather than their mental state or stress level, participants preferred to talk and visualize their level of busyness. All interviewees except for one stated that stress was not perceived as something you wanted to share since it is private, but communicating how busy they felt could be beneficial. It was considered as useful information for others to be aware of, and would explain, e.g., why someone did not want to talk or appeared grumpy. The participants further expected to have less distractions and to stay more focused when using such a wearable, which was the primary reason they found the idea appealing. From the participants' visualization sketches, a preference for the use of a horizontal indicator bar or a 'traffic light' visualization using colors (green, yellow, red) to indicate one's busyness emerged. As participants argued, the signaling colors would allow the easy decoding of information, since it would be universally understood. Participants' wished that the indicator would be attachable to the clothes and not to be too obtrusive.

The Busy Necklace

Based on the interview results, we designed different versions of the *BuSiNec* display in a rapid prototyping session (cf., Figure 3(a)). After weighing the pros and cons for each prototype and iterating its design, we then created the final version of the busy necklace (cf. Figure 3(b)). The round wooden necklace consisted of three color sectors, red, yellow and green, indicating different busyness levels (Figure 1. On top of this, knob and wooden mask layer were attached such that by turning the knob, only one color sector was exposed. To improve the understandability of the display to observers, the word *busy* was engraved at the top of the color wheel.

Creating the Prototypes

When designing the busy necklace, we were conscious of the findings from prior art, that has emphasized requirements for wearables to be aesthetically pleasing and fit with the overall outfit of the user [29]. Guided by Harrison et al.'s exploration on display position for wearable displays for information visibility [25] we selected a pendant type necklace form factor. Hence, we sought to create a design that would be initially perceived as a jewelry type necklace, utilizing aesthetic materials and outlook (Figure 3(b)). Prototypes were manufactured by laser cutting the two main parts from 1.5 mm birch plywood, which were then hand-sanded. The body of the necklace was engraved and painted. The necklace body and mask pieces were connected with a nut and bolt with a washer in between to allow the top part to rotate smoothly. The metal nut was covered with a 3D-printed cap which created a knob to turn the mask layer of the prototype. The manufacturing process is depicted in Figure 4.

EVALUATION

To explore the effects and experiences when using the busyness indicator wearable *BuSiNec*, we conducted a diary study, which was then followed with focus group sessions.

Study Procedure and Participants

To evaluate the Busy Necklace we recruited participants in the same workplace to wear the necklace, and asked them to keep track of their experience in a diary (Figure 5). The pre-printed A5 sized diary included one spread of questions for each day, which participants were instructed to fill in at the end of the day. The diary included 13 questions for each day and also included spaces to allow sketched thoughts about the concept's use. The questions addressed the participant's reflections and perceptions, the use contexts and purposes, other people's reactions, and design suggestions. For the two questions referring to the perceived usefulness and the comfort, participants were asked to rate them on a Likert-item scale ranging from 1(=not useful at all, very uncomfortable) to 7

(a) (b)

Figure 4. The manufacturing of the prototype consisted of different steps. The background plywood discs needed to be painted before the second layer was fixed with a screw (b); a white knob was finally attached to the screw to facilitate rotating the second disc (c).

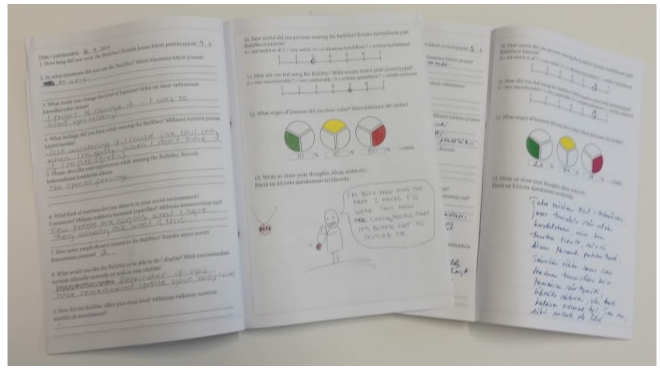


Figure 5. Diaries filled out during the study duration.

(=very useful, very comfortable). In addition, for each day, the participants were asked to give a percentage value on how much they had used each busyness indication state (green, yellow, red), as well as the estimated total time they had used the necklace. The target number of usage days per-participant was five days, which was matched by the number of pages in the provided diary. However, in practice the number of usage days varied between participants, since some wished to wear the device for more or less days.

Altogether, 18 participants took part of the study (13 females) aged between 34 and 61. All of them knew each other as members of the same work community, which consists of a total of approximately 65 employees who share the same office building including a cafeteria and a coffee room. The necklace was used at the workplace premises, where encounters between people (both participants and non-participants) happened as part of normal daily routines. Of the 18 participants, 14 participants returned a completed diary (participants ID 1-14). After the study, two group interview sessions with the participants were conducted to collect feedback on the experience (n=8). For those participants who were unable to attend, we organized individual interviews (n=2). In the interviews we addressed the same aspects as inquired in the diaries. These contained nine questions related to the perceptions and experiences while wearing *BuSiNec*, further reporting on the effects of interpersonal communication at their workplace. The sessions lasted approximately 45 minutes.

Data Analysis

From the returned diaries, we aggregated all data on a per question basis. Quantitative responses were numerically combined over all participants. For the participants' qualitative statements, an open coding approach was used to develop themes. The statements were then coded according to the developed codes.

FINDINGS

In the following, we present the results of our field study, including data from the diaries and focus group interviews. We report on the usage behavior, personal and interpersonal effects as well as impacts at the work community level.

Usage Behavior

As we aimed to capture genuine usage behavior, the study participants were free to decide how much and in which situations they wore the prototype *BuSiNec*. From the diary entries it could be inferred that they used the *BuSiNec* 4.00 days on average ($SD = 1.35$). Eight participants wore it for four or five days, and the remaining participants for between one and three days. The total number of usage days over all wearers was 44 days. All users wore the wearable self-adjusted display throughout their working days and their work activities, such as in their offices, while teaching students, during lunch and coffee breaks, and even during meetings and workshops. Based on participants' estimations, the mean usage time of the *BuSiNec* was 6.55 hours per day ($SD = 3.63$). While one wearer admitted to have forgotten to take it on one day in the morning, four others reported to continue wearing it after work. Revealing more details, two participants mentioned that their kids "*understood the color coding immediately*" (P12). P3 said that for her 6 year old daughter it was easier to notice when they were in a hurry due to the red color. Correspondingly P12's kids reminded her to change the color in the evening, since she was "*no longer in a hurry*" from her kids' perception.

Inquiring what exactly had initiated changes in the color and respectively indicating the level of busyness, more than one third of the users (P2,P4,P10,P13) named that they changed the busyness level display to red when they had specific tasks or "*urgent duties*" (P2,P10) to do. Those activities for which they adjusted the prototype according to their needs, had been for example phone calls, prototyping, reading or processing papers, or simply being in a hurry as P3, P5, and P12 admitted. P3, P9, and P11 used the wearable display to let others know whether they had time for them or not corresponding to having the "*feeling to be more/less busy*". Five participants agreed on showing green when they went to coffee breaks or lunch (P4,P7,P9,10,P13). For 27% of the usage days over all wearers when the *BuSiNec* had been worn, participants reported that they did not change the color because their subjective feelings had not changed either or some just had forgotten to adjust it in the particular situations. The reported use of each busyness status color during the study per participant is shown in figure 6 (participants 1-14).

Increasing Self-Awareness

The most frequent feedback on wearing the necklace was that it made the participants aware of how they spend their time. Participants commented that when adjusting the busyness level they stopped to think whether they were truly as busy as they felt. This conscious occupation supported their reflection on their perceived busyness level and respectively, made them think of whether they should continue more relaxed. For example, P8 (diary) commented that "*it made me think about how real the busyness is*", and "*[the necklace helps] then to remember that I am here for the students and the work community and that it should not be that way, that I am so busy that I don't have time for others*" (P16). Many participants emphasized that *BuSiNec* turned out to be a tool for managing busyness and stress. By manually adjusting the busyness level, the wearer was forced to make a conscious action and to reflect on how busy they felt, and consequently, why they felt so. A typical comment being, "*I have a habit to make a to-do list for the week, and then be like help, so many tasks still left to do. But then [with adjusting the necklace] it felt that actually I have time to do all these things.*" (P11). P9 confirmed that she felt, when she turned it to green, she was "*more relaxed and in red [she is] more focused and feeling more busy*". P10 added that the conscious change of the color fitting the change in oneâĂŹs mind regarding feeling busy also "*eases your mind, when you know whatâĂŹs going on*". One participant even stated that "*BuSiNec helps me also recognize the not-busy moments*". The participants also stated that they started to reflect on what kind of impression they wanted to give to others. A teacher commented, that she was about to set the necklace on red, but instead, stopped thinking that if she signaled she was too busy the students would not dare to come to talk to her. So, she adjusted the color to yellow, and sometimes even to green.

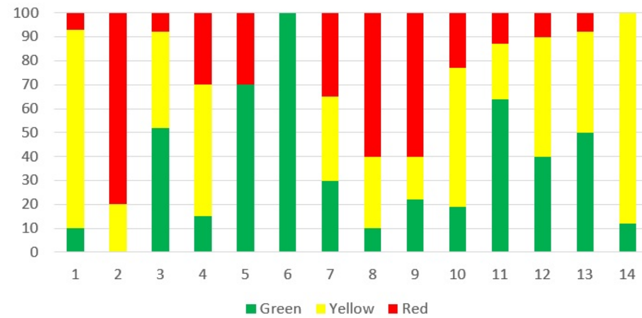


Figure 6. Reported use of busyness indicator colors per user during the diary study; green signifying to be not busy, yellow indicating that one does not have much time, and red referring to a busy state.

The participants further named several occasions where they had noticed someone else who's necklace indicated that they were busy, and knowing that had made the interactions smoother and quicker in a positive and more efficient way, "*On some occasions [anonymized] rushed into my room, and she also has the necklace, and it is always on red. It gave me the feeling that let's get this thing done fast so that she gets to continue her work quickly. [...] And we got it done faster*" (P6). Another participant commenting, "*When someone else had the necklace also, you could time your own conversations and chitchat and disturbance to be the right length*" (P15).

Interpersonal Effects

The study revealed a strong tendency towards using *BuSiNec* to influence the behavior of other people around them. Apparently, the users were aware of this since they admitted to find this aspect interesting and useful. They said that "*it was especially interesting to see how others reacted to me wearing the necklace display, to see if it worked for that kind of purpose*" (P3), and that "*it was really interesting to see how others reacted to the necklace. Maybe that was the best thing with this [experiment of wearing the necklace]*" (P2).

Moreover, the busyness necklace was seen as an opportunity to signal to other people, that they did not want to be interrupted. For example P6 said: "*It is a nice thing that you can communi-*

cate your own willingness to be responsive and your busyness to everyone who is around you. As there are anyway people constantly at my door and knocking there, this [BuSiNec] could provide a solution for this [to prevent constant interruptions]". Another participant commenting similarly explaining that "*it is kind of like someone sitting in the office with headphones in- that is an indicator that I should not interrupt this person as it gives a visual message signaling that the person does not want to be interrupted now*" (P15).

The participants named several occasions where they aimed to change other people's behaviour with the busyness level indicator. Here, the user was trying to make the others subtly aware of their busyness, e.g. that they needed to hurry away or cut the conversation. As an example it was commented that, "*I used the red in that kind of situations where I had agreed on some meeting where I was in hurry to go, to get out of the situation [and start going]. Also to signal that I would like to stop this [what ever situation was on] now and now I will go somewhere else*". One participant had tried to signal in a meeting that she really should start going, and adjusted the necklace first to yellow and then to red. She intentionally did this in a visible way, and by doing it, she had hoped others to notice she was getting busy and needed to leave the meeting soon. However, in this case, the other, who didn't have a necklace, did not react to the hint. Another participant commented that she had started using the necklace also at home to prepare her children to an upcoming actions, e.g. getting ready for the car, "*Now we start to be in hurry, we are shifting to the red now*". The children had quickly learned the new routine, and after a while, the children started asking their mother, how far they were on the busyness levels "*they started asking me, like, mum, are on red yet?*" (P3). Also P12 commented using the necklace at home with kids: "*My ten year old child was really interested in it, and understood the color coding immediately*".

Community Aspects

Participants mentioned several times how wearing the necklace had a positive impact on the group experience level in the work community. As the participants were at the same workplace, they met at the coffee room and bumped into each others in the corridors. The necklace and displayed busyness level gave an easy topic for discussion and facilitated starting conversations and social interaction. For instance, it was commented that, "*the necklace created coffee table discussions 'ah, you have also a necklace, have you been busy?'*", and , "*someone who did not know about this first commented 'Hey you have a new necklace!' [...] and only after then we started to discuss, and then that inspired to discuss other things as well.*" (P2).

Participants mentioned that wearing the necklace on red was perceived to ease communication and give justification for their hurried behavior, "*it made it [my behavior] justified, I have communicated my status to others, and they know that I just handle this action quickly and then I'm gone as soon as possible, and I don't have to stay around explaining that I am busy.*" (P6). Another participant commented similarly, "*it prevents from getting the feeling that I am rude when I say that I need to go because I am busy, or I don't have time to talk with you now. It could ease the communication*". One the other hand, one participant commented that displaying a low busyness level could cause negative reactions on people around. It was commented that "*if one walks here on the corridors with a green set on, do the others start thinking well, that person doesn't seem to have enough work to do*" (P15).

Public Reactions

The reactions, or the lack of them, in surrounding people was commented on several times. The familiarity of the necklace, especially if the other person him/herself was wearing one, triggered conversations and also ability to 'read' the code easily in social situations. It was noted that other people, who were not familiar with the necklace, did not necessarily pay any attention to the necklace display. This was observed, e.g. in situations where the study participant had tried to specifically signal to them that they were busy.

Participants also commented that the necklace had provoked many curious reactions in others. They had noticed it and asked what it was, and the reactions were every time reported to be delighted and excited. For instance, "*I was in this event with lot of people, and immediately there were people saying 'Lovely! What do you have, how is it done?'. And when I explained it more deeply like what this is used for, people where mostly really admiring it and delighted, [saying] that is was a lovely idea and really a nice thing*" (P11).

Despite the overall very positive feedback, users also faced unpleasant situations while wearing the necklace. It was commented that people came really close, touching and grasping the necklace, which was perceived as uncomfortable by some. P9 reported that a curious bystander grabbed the prototype to have a closer look, which made her feel uncomfortable given that the wearable display hangs closely to the chest, a particular sensitive body region for females.

Feedback on the Design

The design of the necklace was generally much liked, although having it as a pendant was criticized by several participants. Especially, wood as the construction material gained much praise. For instance, participants stated that: "*As an object, this is nice as this is made of wood. It feels nice to touch*" (P16) and "*One big positive aspect [in the design] is that this was made of a material from nature. It felt that this contributed to a calming feeling*". The traffic lights metaphor for colors was generally very well understood and liked. However, some other suggestions were also given: "*It would be nice if the colours were sliding / gradient*" (P3).

The pendant type form factor was not everyone's favourite arguing for example, that " *it should not only hang from my neck. Could it be e.g. brooch?*" (P9, diary). It was also commented that female users might find it uncomfortable if the display was close to the chest. On the other hand, it was also said that the necklace was perceived to have more of a feminine design and form factor, which did not suit men so well admitting: "*It is more rare for men to wear such big wooden pendants.*" (P15, male), and "*I would clip it somehow behind the shirt pocket*" (P6, male).

Technology Related Feedback

Some technology related comments were raised in the diaries, and participants' attitudes towards integrating technology with the concept was asked in the end interviews. Generally, interviewed participants were against automatically updating the busyness level display based on sensors, e.g. from physiological measurements. It was perceived as very important that the wearer him/herself had the control what to display. Participants felt there must be possibility to adjust the level manually as they wished.

There were however some concepts, where technology integration and 'smartness' was seen to add value. Automatic color updating was though to be potentially useful if the user him/herself forgot to update the display state, and the displayed information was then misleading (P15). Also getting a reminder for an upcoming meeting was mentioned: "*If it automatically changed the color, and was on red, and when you had been stuck on a coffee table for long, the other could mention that 'hey, how about you, you seem to be in hurry now'*" (P3). On the other hand, some participants were clearly against of automatic visualization based on a calendar, arguing for instance: "*That is two completely different things, what you have in your calendar [and how busy you feel]. It can be more real busyness when you feel being busy, you can get your heartbeat up even though [based on your calendar] you don't have any more [hurry] than the others. If you feel the pressure*" (P16). The non-technology approach raised several positive comments: "*It has good sides being not electric and changing the busy feelings by itself. This way you need to be more conscious of your busy feelings*" (P1).

DISCUSSION

Based on the findings from the diary study and the interviews, we discuss the main observations and implications for prospective design recommendations.

Establishing a Busyness Management Tool

It was unanimously highlighted by the users that the manual adjustment of their busyness level triggered them to reflect on their perceived stress level. The opportunity to become aware of one's inner state through a conscious action was named as the main benefit when wearing *BuSiNec*. By this, the response pressure, which has been shown to exist by prior work [12], could be stemmed. The mere initiation of the reflection process is a crucial factor for refocusing one's behavior, and a step towards managing issues [30]. The usage of the busyness level indicator was further perceived as a self-monitoring exercise. There is extensive related work on the effectiveness of self-monitoring e.g. on weight management [9] and physical activity [10], which has generally reported positive results. Although, four (22%) of our test participants doubted that wearing the BuSiNec had a significant effect on their stress level, almost two thirds perceived the effects of the BuSiNec on their stress level as "*positive*" (P5,P11), and "*lowering*" (P5,P10). Further, statements referring to the increased consciousness of one's own feelings (P9,P10) demonstrate that the effectiveness of the *BuSiNec* varies between individuals and depends on the usage intensity. Nevertheless, we believe that our prototype can at least shift the user's focus to his or her busyness.

Self-reporting vs. Automated Setting of Busyness Level

The fact the participants were manually setting their busyness status, supported not only reflection, but also granted the participants control over the impression they wanted to create in public. Different levels of automation and user autonomy have also been discussed already in the early works on context-awareness [5]. As Li et al. [33] emphasize, for the design of personal informatic systems, an appropriate balance of automated technology and user control should be applied. This consideration becomes increasingly important in the case of a busyness indicator, where the workplace context and work community may set expectations regarding one's behavior and the expected level of busyness. Some study participants used the possibility to signal their limited availability intentionally, e.g. in a meeting or in their function as a teacher. According to their statements, the success was dependent on whether the bystanders used the *BuSiNec* themselves. However, in informal situations such as the coffee kitchen, wearing the necklace also raised the interest of non-participants and stimulated discussions beyond the study participation on one's understanding of busyness. However, this observation shows that our prototype had interpersonal effects also on the community and in some cases even supported the mutual consideration for each other's status as mentioned by the participants. Manual control over the displayed status, which provided subtle hints to co-workers regarding one's availability, turned out to be most important issue. The overall concept was highly appreciated, since showing cues that you were in hurry was seen as a way to smooth social situations and manage other people's expectations. Managing expectations has been noted in early works on context-awareness, where Schmidt et al. [47] presented a mobile phone, which displays information about the busyness of the call receiver.

Influencing Community Behavior

Another valuable finding from our study was how the wearable busyness display affected the community. The range of issues and how strongly they were felt by the participants was quite surprising to us. There were a number of positive effects on the community reported due to wearing *BuSiNec* in public. Providing subtle cues to smooth the encounters, encouraging and discouraging conversations, and facilitating the initiation of discussions were the salient themes.

We consider that our study setting, with a relatively large group (18) of simultaneous participants wearing the prototype at the same time for a week at the office, was key to the success of the experiment. There were sufficient participants and time for both planned and random encounters and different situations typical for office life in which the participants could experiment using the wearable display and apply it to their activities for real. As the people knew each other, some being closer colleagues, some less so, there could be observed interpersonal effects on different levels.

The busyness status was commented in encounters, and it gave a topic to start discussions. Approaches to using technology for starting and facilitating discussions in the workplace have been reported also earlier. For instance, McCarthy et al. report how a public display at the workplace presenting photos of the people sharing the same office building facilitated conversations between people [40]. The fact that several of the work community members were participating on our experiment and were wearing the necklace was said to improve the feeling of community. Prior art has reported improved group cohesion and the feeling of being connected with the peers among sport people when sharing the performance data [20, 56], also when the sharing happens through wearable public displays [39].

DESIGN RECOMMENDATIONS

Based on our findings, we draw the following design recommendations for wearable displays presenting stress and busyness related data.

Provide opportunities for self-reflection. We found out that the act of manually setting the busyness level made people to think and reflect on their perception of busyness and stress.

Allow people to control their status visibility. Manual control of one's displayed status should be enabled.

Design not only for the user, but also for managing the behavior of the surrounding people Remember, that wearing a display also influences on how other people may behave towards you. It can, e.g., invite or discourage conversations.

Facilitate the adaption to personal outlook and style. For wearable items, it is important that people feel that the device matches with their personal style, e.g. in clothing and accessories. Aesthetics, material selections, and the ability to personalize how the display is worn are important factors.

Remember that locating the display has both practical, social and cultural aspects. Location of the display should be both practical and discreet. Consider the position of the wearable display on the body to prevent uncomfortable feelings if someone stares at or touches the display.

Limitations and Future Work

We acknowledge that our research represents the subjective experiences reported by a limited number of participants. Despite the small sample size and the particularities in the data collection, we believe to have captured interesting insights from an extraordinary field study. Due to the nature of in-the-wild studies, there are always risks in participation or reporting the activities. This was realized with user diaries, as only 14/18 participants returned them. Practicalities also limited collecting feedback through interviews, as despite the several attempts, we were able to interview only 10/18 participants. However, through the combination of methods we collected feedback altogether from 18 participants.

As future work, it would be interesting to conduct a user study with an electronic version of the *BuSiNec*, and explore boundaries of manual and automated busyness status setting. Also, the necklace could at the same time function as an input device for collecting data. Making the busyness status visible for others could also function simultaneously for recording the perceived busyness data for later self-reflection. Apart from the named improvements that could be addressed by future research, we believe that particularly the concept represents a valuable starting point for prospective work on busyness signaling wearable displays.

CONCLUSION

By this work, we present a contribution embracing the prototypical design and concept of a jewelry type wearable display the *Bu*syness *Si*gnifying *Nec*klace, or *BuSiNec*. We evaluated our prototype in an in-the-wild user study exploring the users' communication of inner states to their environment. Since we chose a public setting in a work context, we are further able to provide insights in the interpersonal effects affecting the community and provoking reactions by colleagues. From the self-reports of 18 participants taking part in the study, we collected feedback on the experiences and perceived effects they encountered while signaling their subjective level of busyness using three colors. The findings show that *BuSiNec* helped the participants to reflect on their busyness and stress level. The conscious adjustment of one's perceived feeling in form of an easily comprehensible traffic light color code was appreciated, interviewees' anecdotes highlighting that even their kids understood their availability indication immediately. Thus, we envision that *BuSiNec* has potential as a tool for managing the perceived busyness. Further, it became clear that the wearable display affects the behavior of co-located people. The wearers also used the busyness display to provoke or invite certain behaviors in others, such as stopping or starting discussions or meetings. The wearable busyness necklace also stimulated and facilitated discussions making people talk to each other more, which had positive effects to group cohesion and the workplace atmosphere ranging even to an increased mutual consideration for each other's inner states. In general, the concept and design of the *BuSiNec* prototype was considered appealing for its aesthetics and material choices. Based on our findings, we provide five design considerations for wearable displays presenting busyness and stress related data. Through this work we provide fruitful insights for research on wearable displays for self-reflection. Our work opens meaningful research questions, e.g. on the automation level of displaying wellness data, to be addressed in future research and represents an important contribution to the design of wellbeing applications.

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