Tiny Habits in the Giant Enterprise: Understanding the Dynamics of a Quantified Workplace

ABSTRACT

We offer a reflection on the technology usage for workplace quantification through an *in the wild* study. Using a prototype Quantified Workplace system equipped with passive and participatory sensing modalities, we collected and visualized different workplace metrics (noise, color, air quality, self reported mood, and self reported activity) in two European offices of a research organization for a period of 4 months. Next we surveyed 70 employees to understand their engagement experience with the system. We then conducted semi-structured interviews with 20 employees in which they explained which workplace metrics are useful and why, how they engage with the system and what privacy concerns they have. Our findings suggest that sense of inclusion acts as the initial incentive for engagement which gradually translates into a habitual routine. We found that incorporation of an anonymous participatory sensing aspect into the system could lead to sustained user engagement. Compared to past studies we observed a shift in the privacy concerns, due to the trust and transparency of our prototype system. We conclude by providing a set of design principles for building future Quantified Workplace systems.

Author Keywords

Quantified Workplace, Empirical Study; Social Sensing

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

The collective behavior of employees within an organization shapes the organization culture and has proven to play a critical role in organization's success [18, 33]. Significant effort has been put into understanding how the collective behavior patterns - energy levels, unspoken and implicit signaling, and activity dynamics across employees - can directly affect employees' productivity [6, 34, 35]. Besides, there are also environmental factors that influence the productivity of the teams in an organization. For instance, by examining the impact of noise and temperature in the workplace, Mak et. al. concluded that low productive employees are easily influenced by background noise [29]. Kuller et al. [24] and Kwallek et al. [23] explored the role of color and light in the workplace and showed how different interior colors influence the mood of the employees, and affect their productivity. These past studies clearly demonstrate that by quantifying collective behavior and various metrics, a reliable and illuminating picture of the hidden workplace dynamics can be uncovered, which in turn can be converted into actionable insights. Some of these insights can immediately be used to change the physical nature of the workplace, or to increase the informal communication level within the organization. Our investigation continues the tradition of past studies examining technology for workplace quantification, however by carefully applying non invasive passive and participatory sensing principles.

We had the unique opportunity to deploy a Quantified Workplace system, as a technology probe to collect and visualize various workplace metrics (noise, color, air quality, self reported mood, and self reported activity) in two European offices of a research organization for a period of 4 months, survey 70 employees, and then interview 20 employees in detail about their experience. We sought to understand what workplace metrics are useful and why, how employees engage with the system and what privacy or other concerns they have. Our research questions were:

1. Which metrics in a workplace should be measured that employees would find beneficial for their productivity and awareness? Prior studies have examined the role of environmental factors (noise, temperature, color) [23, 24, 29] or mental well-being (e.g. mood) [20] on employees' productivity. We broaden this focus to understand from participants (both employees and management) which workplace metrics are useful to them and why?

2. How do employees react to data visualization and two different data collection strategies, i.e., passive sensing with sensor infrastructure, and participatory sensing with wilful engagement in a Quantified Workplace system, and how these behavior affect the sustained usage of the system?

3. What privacy concerns do employees have with various workplace metrics? Recent studies on people analytics in an enterprise setting have raised substantial privacy concerns albeit obvious benefits [6, 34]. Focusing on environment factors (noise, color, and air quality) and anonymous collective behavior (mood, and activity), we wanted to re-examine the privacy space for a Quantified Workplace system.

Our study findings suggest that collective experience of inclusion through anonymous participation acts as the primary incentive for employees to adopt the Quantified

Workplace system initially, which overtime translates the participation into a sustainable *tiny habit* [43]. Our participants showed a preference towards quantification of metrics which are beyond a human's natural sensing capabilities, and also highlighted the negative effects of quantification if users are unable to act on its outputs. Perhaps the most dramatic change from past studies is the shift in privacy concerns - while the idea of the Quantified Workplace strikes some people as a *big brother*, what we've found is that, if approached in the right way with trust and transparency through anonymous data collection and real time visualization - privacy concerns can be addressed in a way that makes everyone comfortable with a Quantified Workplace system.

RELATED WORK

Over the years, there have been various technology interventions in the workplace with varied focuses including improving socialization and collaborations [15], providing connectivity and awareness across remote locations [11], promoting informal lighthearted conversations and playfulness [17]. While these studies and others highlight interesting aspects of technology use in the workplace, most relevant to our study is the research on the rise of Quantified Self movement and its extension to Quantified Workplace.

Quantified Self Movement

The Quantified Self [37] is a movement that promotes the use of technology for self-tracking various kinds of personal information, such as physical activities, emotions, diet, etc. Due to the potential of self-tracking in promoting intentional behavior change, researchers have looked at incorporating both passive and participatory sensing in designing self-monitoring technology. Past research have studied many self-tracking technologies in the domain of health and wellness for tracking physical fitness [10, 28], diabetes care [36], sleep [21], diet [30], stress [32] and smoking [2]. Li et al. have characterized self tracking activity in a 5-stage model (preparation, collection, integration, reflection, action) to better explain the psychology behind it. In a recent work, Choe et al. [9] analyzed 52 video recordings of Quantified Self Meetup talks to understand the common pitfalls of *Quantified-Selfers* and concluded that over quantification (i.e., tracking too many metrics resulting in tracking fatigue), ignoring situational context and lack of scientific rigor regarding data interpretation are the primary barriers towards successful adoption, and sustained usage of these technologies. Taking a critical standpoint, Rooksby et al. [40] argued that self-tracking technologies should be considered more social and collaborative, and their evaluation should also consider hope and playful feelings they generate among the users, instead of just evaluating the *improvement* of a certain metric. Albeit the focus of our study is on workplace quantification, the findings of these studies greatly influenced the design decisions for our prototype Quantified Workplace system.

Quantification at Work

While the Quantified Self movement has really taken off, the notion of a Quantified Workplace is in a relatively nascent stage. The technology blog, Gigaom [41] envisages Quantified Workplace as an extension of Quantified Self, with the aim of promoting health and wellness at the workplace. In the academic literature, however, there are a number of past studies that have investigated physical quantification at a workplace from a number of different perspectives. In [12], a sociological survey of 274 knowledge workers in the Netherlands shows that the physical and social environment at work do have an impact on the creativity of employees. Kwallek et al. investigated the impact of color on employees productivity [23]. In that research, 90 workers were treated to three identically furnished, but differently colored offices (red, white, blue/green) and it was reported that red interior has a strong negative impact on moods, while green has a positive impact. In a survey based study with 259 office workers in Hong Kong, Mak et al. found that sound and temperature were the principal environmental factors affecting office productivity [29]. Although interesting, these studies rely on ethnographic observation and surveys, which unfortunately suffer from biased results either because participants adapt their behavior during observation [45] or they tend to provide socially desirable responses [4].

In the UbiComp literature, Efstratiou et al. [13] have explored the benefits and privacy concerns with passive sensing in the workplace in a two week study. They found that comparison of self with others was considered a major benefit of the system, and lack of control over the sensor data collection was a significant privacy concern. A number of works also explored different technology probes to increase group communication either through active sensing or by introducing playful artefacts. Olguin et al. [34] have looked at using wearable electronic badges for measuring face-to-face interaction, conversations and physical proximity. Brown et al. took a similar approach of using wearable badges to track serendipitous interactions in a workplace and evaluate the effect of worker's cultural backgrounds on interaction diversity [6], and to study how the physical design of workplaces combines with organizational structure to shape contact patterns [7]. In [17], Gallacher et al. make use of multicolored squeezy balls to elicit mood inputs from the employees. Arnie [3], a talking beer vending machine, was designed to attract employees into common areas for an opportunity to chat with colleagues. The Break-Time Barometer [22] was a persuasive technology to motivate people to come out of their offices and socialise more. These works however were primarily short research studies, focusing on measuring the impact of a particular metric in the workplace. Grounded upon their findings, our work is focused on adding to the knowledge for the development of a *holistic Quantified Workplace system* through a real-world deployment of a technology probe in two offices spanning over four months, which allowed us to explore issues of sustainable usage, identifying useful workplace metrics and privacy concerns more objectively.

A PROTOTYPE QUANTIFIED WORKPLACE SYSTEM

The main objective of our technology probe is to explore various aspects of workplace quantification by taking a systematic approach, and to gain deeper insights that would

Metric	Type of Sensing	Expected Utility	Expected Privacy Concern
Air Quality	Passive	Health, Wellness	Low
Noise	Passive	Workplace Awareness, Informed Decision	Medium
Color	Passive	Playfulness, Mood Influencer	High
Activity	Participatory	Workplace Awareness, Comparison of Self vs. Others	Low
Mood	Participatory	Self Reflection, Workplace awareness	Medium

Table 1. Description of the Collected Workplace Metrics

inform future design of Quantified Workplace systems. As such, we looked at the system design from two aspects, i) *Data Dynamics* - which workplace metrics should the system collect and visualize, that would have varying degrees of usefulness, and privacy concerns for the employees and ii) *Engagement Dynamics* - what strategies to follow to collect these metrics, and with what level of engagement from the employees. Our design challenges were to systematically explore these options to build a technology probe that would give us deeper understanding on the user experience, and concerns of workplace quantification technology. In the following, we discuss these design challenges, followed by the explanation of the system implementation and deployment.

Design Challenges

In this section, first we discuss the different workplace metrics that we collect, and the rationale behind it. Next we discuss how these metrics are collected, i.e., what sensing and engagement strategies are used.

Data Dynamics

Past ethnographic studies have looked at various environmental factors, such as noise and color [23, 24, 29] at workplace and found that these factors do impact workplace productivity as well as increase the awareness of the employees. Similarly, visualizing indoor air quality in the workplace has shown to be useful to the employees [8]. Looking through the privacy lens, the former metrics are comparatively privacy invasive to the latter one due to the data modality, e.g., audio and video data. While there are other environment metrics such as nature and layout of spaces [1], brightness, humidity, etc. that influence organization culture, in this study we limit our environment data collection to noise, color, and air quality as they provide an excellent case study due to the nature of data, their usefulness and complementary privacy sensitivity.

To understand collective behavior pattern within an organization, past studies have logged face to face interaction data [6, 34, 35], mood and stress data [17]. While face to face interaction data has been shown to be extremely valuable to understand organization dynamics and productivity, it comes at the expense of employees' privacy erosion. On the other hand, a soft metric such as mood, when measured collectively has shown to be less privacy sensitive. In our study, we decided not to collect personal interaction data, as we argue this would affect user engagement with the overall system, in which other metrics are not tied to individuals. We therefore chose to quantify moods, gathered collectively, to examine its impact from both usefulness and privacy perspectives. In addition, grounded upon the insight of Efstratiou et al. [13] that employees often prefer to compare themselves against others, we decided to gather *work activity* data, again in a collective fashion. These metrics are further discussed below from a utility and privacy standpoint, and summarized in Table 1.

1. Air Quality: We measure the air quality (CO_2 levels) in the office. This information could be considered useful for health and wellness reasons. We hypothesize that air quality measurement would not be considered privacy invasive by employees.

2. Noise: We measure the ambient noise in the workplace. Intuitively, we expect that employees can utilize the noise information to decide which areas in the workplace are better suited for them to work, e.g. if they prefer to work in a quieter area, they can look at the real-time noise map and choose a suitable area. Noise information could potentially also help the management to plan the workspace layout and sitting arrangements. In terms of privacy, noise measurements may be considered invasive, as employees might fear that the system is capturing audio conversations.

3. Color: Past studies were primarily concerned with the interior color [1, 23] which in most cases are static. Delving upon the findings from a recent study that suggested that color of surroundings in urban spaces have a strong effect on an individual's feeling [38], we collect the color of clothes worn by the employees, and aggregated to determine a set of dominant colors in the workplace at any instance of time. In terms of utility, we concur that employees would find it playful to know the color of the workplace, and it may lead to informal conversations. From a privacy perspective, color measurement could be considered highly invasive as it requires capturing a visual image of the employees for color analysis.

4. Mood: Mood inputs are collected with a self reporting approach (see next section for more discussion on engagement). Employees are presented with 8 moods to select the one that reflects best their mood at a point of time. We sampled the moods based on Russell's Circumplex model of affect [19] from the behavior psychology literature. Mood could be beneficial for an employee's self-reflection, and the quantification of mood can provide better workplace awareness. The sharing of mood, a highly personal trait, with the system may be considered privacy invasive.

5. Activity: Activity inputs are collected with a self reporting approach, and employees can select their primary work-related activity in the day from a pre-populated set of 8 activities[1] e.g. meetings, writing, programming, administration. Activity inputs can generate awareness of what's going on in the workplace, and may be considered less privacy invasive.

The final aspect of data dynamics for the Quantified Workplace system is the output modality. Previous studies have reported, insights emerged from workplace quantification has implication to both employees and management [18]. As such, a Quantified Workplace system should explore the preferences of different stakeholders towards visualization of quantified data in a workplace. To achieve this, we deployed two different types of displays for visualizing the quantified data: one was a large screen dashboard which showed detailed visualizations (e.g. various graphs) of the data, while the other was an abstract display with a variable color light, that changed the color corresponding to the dominant mood (aggregated over a time) of the workplace. For mapping mood to a unique color in the RGB spectrum, we followed the guidelines from color psychology [44].

Engagement Dynamics

In the previous section, we describe the different workplace metrics that we decided to collect in our prototype Quantified Workplace system. There are multiple ways to gather these metrics: either by passive sensing with dedicated sensor infrastructure (e.g. array of microphones, cameras and physical sensors to measure noise, color, air quality, mood, activity), or by combining infrastructure sensing with explicit user participation (e.g. self reporting). Previous works [6, 7, 13, 34] have mainly looked at passive sensing either using infrastructure or distributed wearable sensors (e.g., RFID badges) as a data collection methodology in a workplace. In this work, we sought to understand employees' perception towards a data collection process that combines both passive sensing (for air quality, noise, and color), and participatory sensing (e.g., self reported mood and activity). By doing so, we could explore if employees have a preference towards a certain way of sensing.

The latter modality i.e., participatory sensing with self reported mood and activity, raises another design question - *should participatory inputs from employees be solicited through a publicly placed device or through an app installed on their phones?* To arrive at this decision, we piloted two versions of the Quantified Workplace system (described in the following paragraphs) in one of the offices: one as a tablet application deployed on publicly installed Samsung Tablets in the workspace, and the other as a personal mobile app. A one month pilot study showed high engagement with the tablets with 57 daily participatory inputs on an average. The mobile app, on the contrary, got poor reception with only 4 users downloading it on their phones. Based on this finding, we decided to use publicly deployed tablets for collection of participatory inputs in the rest of the study. As we will discuss later, our exit surveys and interviews also confirm this design decision, with 68% of the users saying that they would not install a Quantified Workplace app on their personal phone.

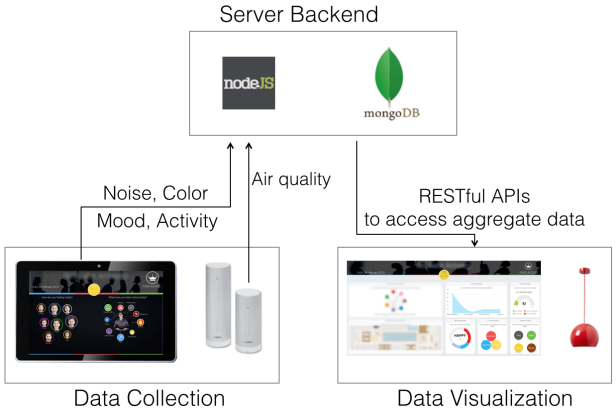

Figure 1. System Architecture

Implementation

We now explain the design architecture of the prototype Quantified Workplace system. Instead of dedicated sensing infrastructure, we wanted to leverage existing commodity hardware in this Quantified Workplace system to keep the deployment costs low with no or minimal maintenance from the management. Our entire setup (for each office) comprising of four commodity Android tablets (used for sensing noise, color, and gathering employees mood and activity data), 1 air quality sensor, 1 Philips Hue Light[2] (used as a color changing abstract display) and 1 LED TV (used as dashboard display) costs around $2000. Furthermore, no maintenance was required from the management, except to provide a power inlet to each device. From a software point of view, as shown in Figure 1, the system consists of three components:

Data Collection: We developed an Android application for passive sensing of noise and color of clothes, and participatory sensing of moods and activities. Using the MediaRecorder class of Android 4.4, we took an audio sample every 15 seconds, which contained the maximum observed audio amplitude near the tablet in the last 15 second duration. For capturing color we used the front-facing camera on the tablet. When we detect a significant change in the reading of ambient light sensor of the tablet, it was assumed that a person is walking by the tablet. At that instant, the front camera (passively) took an image of the scene, which was analyzed to find the dominant color in the image while filtering out the background. The front user interface of Android application is used to collect mood and activity inputs (as shown in Figure 2(a)). After each participatory input (mood and activity), we also ask the employees to select the name of the research division in which they belong, e.g.

[1]The set of activities selected are hand crafted based on the nature of the workplace, a research organization, in which this study was conducted, as such they should not be considered either complete or generic.

[2]http://www.meethue.com

Figure 2. Tablet Application, Dashboard Display, and Mood Lamp of the Prototype Quantified Workplace System

Wireless, Application, etc. Finally, we used the Netatmo weather station[3] to measure the air quality in the office.

Backend Server: All the collected data (environment metrics and participatory inputs) is immediately sent to a Node.js backend server. The server stored the data in a MongoDB database and provided RESTful APIs for accessing the aggregate data.

Data Visualization: We employed two display methods to visualize the quantified data. Firstly, a large-screen dashboard application (as shown Figure 2(b)) written in HTML5 with active polling, showed various charts representing different workplace metrics in real-time - including a noise map of the office, a mood map showing the overall mood of the office, an activity map highlighting different activities of the office, an air quality index, and a color map showing the most popular colors in the office. We also display the name of the research division with the highest number of inputs on a given day. Secondly, we installed an ambient display in the form of a multi-color lamp, which changes its color as per the dominant mood of the workplace as illustrated in Figure 2(c).

Deployment

We conducted an in-the-wild deployment [39] of the system in two European offices of a research organization. Albeit situated in two different countries, these two offices share several common interior constructs, e.g., employee lounge, coffee area etc. To be consistent, we placed the tablets in areas that have similar usage in both offices: *coffee area, printer area, employee workspace and in the largest meeting room*. We intentionally place the tablets close to the coffee machine, and the printer with an assumption that the activities that occur in these area offer momentary opportunity (e.g., idle time while waiting for coffee, or print) to interact with our system. We have observed interesting facts about these placement choices that we will discuss later. The weather station was placed in the *employee cubicles*, while the dashboard and the mood lamp were located in a *employee lounge area close to the workplace entrance*.

[3]https://www.netatmo.com/

STUDY METHODOLOGY

Our study was conducted from October 2014 to January 2015. We collected data in three steps i) system usage logs ii) a survey and iii) semi structured interviews.

System Logs

Over the period of four months, the system passively collected 425,511 noise, 69,159 color, and 46,080 air quality values in 80 working days (excluding weekends and Christmas vacations). It also received 5312 participatory inputs from the users, with an average of 66 inputs/day in a 120 employee workplace (both offices together). As our data collection process was anonymous (recall that we did ask the employees about the research division they belong to, but not their personal identity), the quantitative data alone cannot prove that these inputs were from different individuals. However in the exit survey, 77% of the participants mentioned that they provided only one input per day - which gives an indication that the participatory inputs were well distributed across the employees.

Figure 3 depicts the number of mood and activity inputs to the system. Mood inputs accounted for 73% of the total inputs, while activity inputs made the remaining 27%. Users' preference towards mood inputs was due to the playfulness attached with the mood lamp, and also because mood inputs led to self reflection. This finding will be discussed in detail later in the paper.

Survey

Four months into the deployment, we e-mailed an anonymous survey to all the employees. The survey comprised of 33 questions. In addition to collecting demographic data, the survey aimed at understanding user's experience with the system, including its perceived benefits, trustworthiness, engagement dynamics, privacy and other concerns. In total,

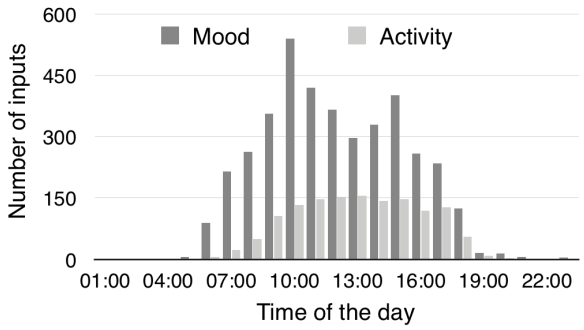

Figure 3. Comparison of Mood and Activity Inputs Received during the Study Period

we received 70 responses to the online survey out of 120 total employees, with 25.7% of the respondents identifying themselves as managers. In total, 85% respondents mentioned that they interact with the Quantified Workplace system: 77% of these respondents provide 1 input per day, 19% provide 2-3 inputs while 4% provide more than 3 inputs in a day. In the next section, we discuss other quantitative findings from this survey.

Semi-Structured Interview

After the survey, we conducted a series of in-depth interviews with 20 employees (9 females, 11 males) aged between 28 to 43 years. For recruiting, we used stratified sampling with snowball sampling within each stratum. During the recruiting process we identified two primary groups of participants that represent the two main roles in the organization, e.g., employees (including research scientists, research engineers, and admin staff) and management. Also, 6 of these participants were from non-European nationalities while 14 were European nationals. The interviews were semi-structured, involved one interviewer and one note taker, and lasted 1 hour each. Similar to the survey, interviews also focused on questions of perceived utility, engagement, privacy, trustworthiness - but with the objective of diving deeper into each aspect. To do this, we followed an interview technique called *laddering* [25], a qualitative research technique which seeks to understand the core values behind the user reactions to any system. Each interview was recorded and later partially transcribed to complete the observer's notes. The participants were compensated for their time with an Amazon voucher.

The results of the survey and the interview together with the quantitive data we extracted form the system logs will be presented and discussed in the next section.

STUDY RESULTS

The system logs, surveys, and interviews gave us a fascinating view on a number of different aspects for the workplace quantification. We now discuss the study results from these aspects.

Understanding Spatio-Temporal Usage

Figure 4 shows the distribution of participatory inputs over time. In the first week of deployment (excluding weekends), a total of 1184 inputs ($\mu = 236, \sigma = 165.2$) were provided on the tablets - this high number could be attributed to the novelty effect of deploying the system. In the subsequent weeks, the usage became more stable and averaged at 294 inputs/week (daily $\mu = 58.8, \sigma = 23$). There was no correlation found between day of the week and the number of inputs (Pearson's $r(80) = 0.06, p = 0.55$).

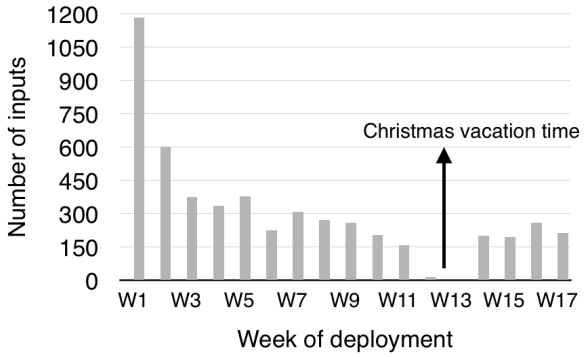

Figure 4. Distribution of participatory inputs over time

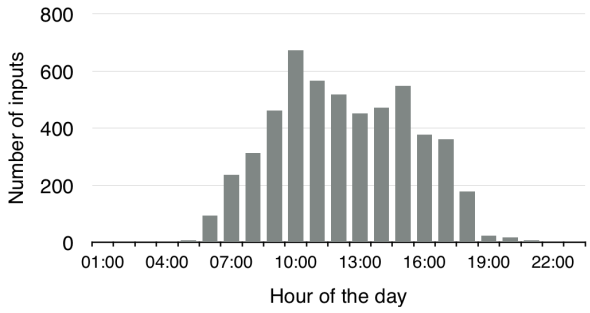

Figure 5. Hourly average of participatory inputs

Figure 5 shows the hourly average of participatory inputs into the system. The inputs were spread across office hours (09:00 to 19:00), with the highest inputs done between 10:00 - 11:00. We found no correlation between hour of the day and number of inputs (Pearson's $r(1920) = 0.04, p = 0.05$). This finding was reaffirmed in our exit survey where 60% of the employees mentioned that they have no fixed time for interacting with the system, rather the interaction happens in an opportunistic manner. Figure 5 also shows a small number of inputs made at late night or early morning, which we believe were from the security and support staff working in a night shift.

The placement of tablets had a significant impact on usage. Based on placement, we classified the tablets in two categories: A) those placed at locations where users may have had some free time (e.g. at coffee area, and at printer area) and B) tablets placed in areas such as meeting rooms and employee workspaces where employees may be busy. With a Welch's t-test, we found a significant effect of tablet placement on the number of participatory inputs ($t(1920) = 15.7446, p < 0.0001$, Cohen's $d = 0.52$) with category A tablets receiving 90% of total inputs. Multiple participants explained this behavior in the interviews, one remark was:

"It's not like I go consciously to the tablet to put my mood. But when I am waiting for my coffee, I have spare time so I always enter my mood and activity..."

There was another interesting dynamic that influenced user participation - the possibility of seeing the mood lamp from a tablet's location. The tablets from where mood lamp was directly visible received significantly more inputs ($t(1920) = 9.4525, p < 0.0001$, Cohen's $d = 0.25$). This result has an interesting implication about integrating playful artefacts in the design of a Quantified Workplace system, which we discuss further in the coming sections.

Understanding Data Dynamics

Of the three environmental metrics we collected, air quality was the most preferred (42% participants found it useful), while noise (21%) and color (13%) were less preferred. Multiple participants commented that while noise and color quantification is informative, both these metrics can also be sensed by bare human senses. On the contrary, air quality is an *invisible* metric and therefore its quantification can be useful.

Our qualitative interviews however reveal that none of the environment quantifications had any behavioral influence on the employees. For color, participants commented that it is a *good to know* metric and may have an indirect effect on individual moods, however in a workplace setting, completion of professional objectives is a bigger motivation than the physical look and feel (e.g. color) of the workplace. Moreover, participants remarked that they need to collaborate with colleagues in the workplace, so even if the quantification shows a certain area as noisy or with a relatively poor air quality, they would still have to go there for collaborations. One participant even highlighted the negative effect of such quantifications:

"Even though noise in my area is very high as compared to other places, I cannot really change my desk ... It is better to not know about the higher noise levels in my area..."

We believe that this is an interesting finding as it shows that quantification can be considered disadvantageous at times, if users do not have the capacity to act on it. Therefore, system designers should focus on *actionable quantifications* in the workplace, i.e. quantification of those metrics upon which users can act.

The management was more open to passive quantifications, with 33% managers finding color quantification, and 58% finding both noise and air quality quantifications useful. Managers were primarily interested in noise data for desk management (e.g. teams which prefer quiet workplaces can be placed in a quieter area of the building), for understanding the impact of noise on moods and activities of the employees; air quality data for health and wellness reasons; and color quantifications to understand if color of the surroundings has any influence on employee's moods and productivity. As opposed to individual employees, management has more authority to act on the quantified data, which increases its usefulness for them.

Our system quantified two participatory inputs from the users: mood and activity, and both were found more useful than the passively collected metrics. Quantification of mood was found useful by 60% employees and 89% managers. Many participants believed that average mood is a reflection of the vibrancy and long-term performance of their workplace. Furthermore, participants considered mood inputting as an opportunity for self expression and self reflection, as remarked by one of the participants:

"You have the feeling that you can communicate your mood and that's a real relief when you are stressed....we should be reflecting on our moods more often, but do we? When I was near the tablets, it gave me a chance to do that..."

Mood quantification was also used by some participants to do a "me vs. rest" comparison, i.e., how is an individual's mood comparing to the rest of the workplace. One remark was:

"Sometimes I see people are stressed at the time of deadlines. But if I am not stressed, I think maybe I should also be stressed..."

For the management too, mood quantification was highly useful. They mentioned that it would help them to find how different teams are feeling over time, impact of building works on employees' moods, and seasonal impacts on moods. They also felt that it gives an opportunity to employees to freely convey negative emotions about the workplace, which they might not do otherwise, and such openness will lead to a better workplace.

Activity quantification was found useful by 58% of the employees and 63% of the managers. Employees found it useful to get an overview of the various activities happening in the workplace and to compare their own activities. Furthermore, participants considered this input as an effective tool to give feedback to the management about the high level activities happening in the workplace. We received a similar feedback from the managers that activity quantification provides coarse level awareness about the workplace on a regular basis.

User reactions on our two data visualization methods revealed an interesting picture. Most employees did not consider the dashboard useful, partly because they had less interest in the passively collected data. But more importantly, they felt that it takes time and effort to understand the graphs on the dashboard, and requires them to purposely stop by the display. On the contrary, management showed more enthusiasm towards the dashboard and the various data visualizations shown on it. They also asked for more details to be included, such as historic trends of noise, air quality and moods.

The mood lamp was well received by both employees and management. They found the concept of mood lamp easy to understand and liked that its output could be interpreted immediately, without requiring users to purposely come near it. One participant commented, *"The mood lamp is easy to explain. Everyone understands it. technical and*

non-technical people....". Another user comment, although negative, reflects the potential of the mood lamp to alter user behavior.

> *"Yes, I'm concerned about approaching the mood lamp with visitors. I was always worried that the it may show a negative mood....I want the mood lamp to give our visitors a positive feeling about the company."*

These observations advocate that user engagement with a Quantified Workplace system could be increased by using a simple, intuitive and playful artefact (e.g. a mood lamp) as an output modality.

Understanding User Engagement

We found that initially user engagement with the system was driven by a collective behavior trait. In particular, it was triggered by a feeling of inclusion. Participants felt that the outputs of the system are a reflection on their colleagues, and that they should be part of it to get an accurate reflection of the workplace. One participant said: *"I believe the outputs are reliable only if everybody is participating in the system, else it gets biased. I do my part regularly...."*

Some participants also highlighted that they want to give a positive impression about their work activities, which led to their engagement with the system. An interesting remark was:

> *"..at times when the mood lamp was showing a red color (associated with 'Stressed' mood), I purposely went and inputted a positive mood, in order to change the color of mood lamp to reflect a happy mood..."*

These findings suggest that the motivation to contribute to such participatory Quantified Workplace systems comes from the desire of expressing a positive behavior collectively.

Participants mentioned that they engage with the system primarily in an opportunistic manner, i.e., when they were near a coffee machine (or a printer), and waiting for a coffee (or a printout), they would often provide inputs into the tablets. This was also evident from our system log as discussed earlier. Interestingly, many participants reported that over time, engaging with the system at such opportune places became a habit for them. One participant mentioned: *"Well, I am at coffee machine every day. So I just input my mood, it's quick, doesn't take my time. I have no reason not to do it..."*

Similar remark was received from other participants. This is an intriguing finding - it suggests that opportune placement of input terminals and rapid interaction time can lead to formation of a *tiny habit* [43] to engage with the system. Fogg's *tiny habit* guidelines include three steps: i) *pick a small task*, ii) *incorporate it in your daily routine* and iii) *celebrate task completion immediately*. Our results clearly suggest that, while in the beginning user engagement was informed by a collective sense of inclusion, over time it translated into a *tiny habit*.

Previous research [17] has shown the presence of honeypot effect [5] in the technology initiatives deployed in a workplace, however our findings suggest an opposite behavior. 92% of the survey respondents mentioned that they used the tablet only when they were alone. This behavior was attributed to the fact that one's moods and activity inputs are private in nature, and participants didn't want to reveal it to their colleagues, more so when their mood was on extreme negative side. However, they were happy to share their true mood with the system as the data was collected in an anonymous manner. We believe that the corporate setting (the previous study was conducted in an academic environment), and its workplace dynamics might have led to such a contrasting result in our study.

We also analyzed our survey data through a gendered lens to determine any effect of gender on the data dynamics. A Fisher's Exact test reveal no significant effect of gender on preferences for noise, air quality, mood or activity (all $p > 0.05$). However, for color quantification, there was a significant effect of gender ($p < 0.05$) with female participants preferring it more than their male counter parts.

Understanding Privacy and Trustworthiness

Privacy concerns among employees can prove to be a showstopper for a Quantified Workplace systems as reported by past studies [6, 34]. In our deployment, we collected various metrics, some of which may be considered privacy invasive as discussed earlier in the paper. In the exit survey, we asked the participants to rate their privacy perception of the system on a scale of 1-5 (with 1 being *not at all concerned* and 5 being *very concerned*)

We found that 50.5% of the participants had little to no concern with the system, 21.5% users were neutral, 24% were somewhat concerned, and only 3% were very concerned. The primary reason for the low privacy concerns, as mentioned by the participants, was that the system collected data in an anonymous manner, and none of the metric could be tied to an individual. 68% of the participants remarked that if the data collection was carried by a mobile application (using on-device sensors for collecting environmental metrics, and self reporting for mood and activity) they would not use it. This was also clearly evident in our small pilot that we have discussed earlier. One participant mentioned: *'On my phone, I would be hesitant to give mood and activity inputs. It's a very personal thing and I don't want the inputs linked to my name..."*

In a similar spirit, another participant said: *'If management has access to this data I feel I won't be inputting my mood because I want to be judged on the quality of my work, not by my feelings..."* . This finding clearly suggests that for a Quantified Workplace system to work, designers should focus on anonymous collection of workplace metrics.

As for the various data we collected, 50.5% users reported that none of the data was privacy invasive, while mood (26.15% users), color (23.08% users), and activity (21.5% users) were found privacy invasive by some users. Noise (9.23%) and air quality (1.54%) were perceived as privacy invasive by the least number of users. This is counter intuitive, in that we initially hypothesized that noise, color

and mood would be considered privacy invasive due to nature of the data, and also the data collection modalities (i.e. use of microphone and camera). However, it turned out to be not true, and again users attributed this behavior to the anonymity provided by the system. Even the minor privacy concerns reported by users were linked to the possible loss of anonymity. A participant said: *"I work in a very small team. Because of the dedicated nature of my activities, it is very easy to trace back any inputs from my team to me*[4]*..."*

This result emphasizes the need to design a Quantified Workplace system by incorporating the principles of *k-anonymity* proposed by Sweeney [42], to ensure that all users are hidden in a sufficiently large group of k people, and it becomes infeasible to link a participatory input to a specific user.

In addition, multiple participants mentioned that the real-time feedback and immediate reflection of their inputs in the dashboard and mood lamp, also helped easing their privacy concerns, as they could clearly see what data is collected and how it is used visually.

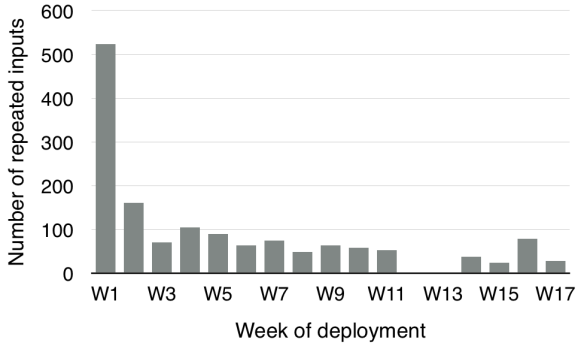

Figure 6. Number of repeated inputs over time

We also probed the users about their perceived trustworthiness of the system. Do they feel that the quantification outputs shown by the system are genuine? Do they fear that an anonymous participatory system is prone to misuse in the workplace? The results are mixed in nature. About 53% users felt that the outputs are not trustworthy. This mistrust was primarily caused due to the initial engagement dynamics of users with the system. At the beginning of the deployment, participants observed many users playing with the system, in some cases they were providing repeated mood inputs one after another, to change the color of the mood lamp. Figure 6 show the number of repeated inputs from our system log. We mark inputs as *repeated* if we observe two or more participatory inputs of same type (e.g. two mood inputs) on a tablet within a span of 10 seconds. As evident in figure 6, the number of repeated inputs was considerably high in Week 1, with such inputs accounting for 44.1% of the total inputs. This negatively influenced the trust perception of the system - one participant commented:

> *'Sometimes I wonder if there is a guy who plays with the system to cheat it, to set a wrong mood. It was a pity that people played with the system and misused it initially..."*

This behavior however subdued in the coming weeks, with repeated inputs falling to 13% of the total inputs in the last week of the deployment - and users felt that the system became more trustworthy. One manager commented:

> *"Yes, in the beginning some people gave false inputs. And as management this caused me to worry. But now I think the data is levelled out. The system can provide a means for anonymous venting, which is a pity. We must be cautious to prevent misuse..."*

To conclude, while in the beginning the system was partially abused, over time participants started using the system more honestly. In addition, the anonymous data collection with transparent realtime reflection of data helped in alleviating any privacy concerns. This can be considered as one of the most important findings of out study, as it clearly advocates that if designed with adequate transparency and by preserving anonymity, the acceptance of a Quantified Workplace system will increase substantially.

IMPLICATIONS

In this section, we discuss the implications that emerged from our study, which we found most compelling.

Design for Participation

With advancements in our sensing capabilities, it is becoming feasible to automatically sense data such as moods and physical activities, without relying on user participation. Our findings however caution the designers against this urge of automating the entire data collection process. We found that the participatory nature of our system interested users the most - it gave them an opportunity of self expression, and at times led them to reflect on their own mood and activity. Participatory inputs also led to several conversations about the system in the employee community, which increased the popularity of the system and drove the initial wave of user engagement. It is important to emphasize that we are not advocating against passive sensing in the workplace. Past research has clearly demonstrated its benefits, e.g. Brown et al. [6] learned hidden interpersonal dynamics in a workplace by analyzing passively collected mobility traces. What we are advocating is to have a balance of passive and participatory sensing in a Quantified Workplace system, which will lead to a sustained user engagement.

A surprising finding of our study was that the opportune placement of tablets and quick interaction time with the system, promoted a *tiny habit* [43] of providing participatory inputs. As such, we advocate that designers of future Quantified Workplace systems should pay particular attention to consider such habitual routines while devising their data collection strategies to guarantee a sustained usage.

Focus on Actionable Quantification

Perhaps the most important consideration in the design of a Quantified Workplace system is to identify what metrics to quantify. While the exact metrics will depend on the goals of

[4]Recall that we asked the users to provide their group name after each participatory input

each system, and the potential stakeholders, our results offer some general insights in this regard. We found that passive sensing of noise, color and air quality was not found useful by majority of the employees, primarily because they felt they had little power to act on the results of the quantification. Some employees even highlighted the negative aspects of knowing about non-actionable quantifications. However, to management these metrics were useful for informed decision making. This suggests that a Quantified Workplace system should focus on *actionable quantification*, i.e. quantification of metrics upon which its stakeholders can act.

Design with Playfulness

A workplace has traditionally been perceived as a serious setting, and playfulness in the office is viewed more as a distraction. However, Lamm et al. [26] found that this perception is changing: while those born between 1941 and 1960 often regard fun as counter-productive, the new generation of workers (born between 1981 and 2000) view it as an important enabler for building social connections and trust with colleagues. Our study findings concur that incorporating a playful artefact such as the mood lamp can increase user engagement with a Quantified Workplace system. The changing color of mood lamp led to many informal conversations about the system in the employee community, and had a significant effect on user participation. Gallacher et al. [17] recently explored the role of playful interactions to encourage openness and social interactions in a workplace. Similarly, our findings provide another example of how playful artefacts can increase user engagement with a technology system in a workplace setting.

Design with Openness

A system like Quantified Workplace is geared more towards community-level benefits than individual benefits, which is often not perceived by the target user group. In our study, we observed that a user tried to hide the camera on the tablet with a spoon, perhaps due to his privacy concerns. We also witnessed a high number of repeated negative inputs to influence the color of the mood lamp, which decreased trustworthiness of the system in the beginning. Our key suggestion here is that designers should be cognizant of the possibility of these phenomena, and attempt to mitigate it by building user trust. We suggest three design principles to increase user trust: anonymity, transparency and inclusion.

Anonymity: Our prototype system provided team-level anonymity to the users, and a vast majority of the users felt comfortable with it. On the contrary, 68% of the users mentioned that they would be concerned with using the system, if it were a personalized app on their phones. Thus, we argue that anonymity is a key design element that can mitigate users' privacy concerns with Quantified Workplace system meant to be deployed in a public setting. Although an anonymous system may be susceptible to misuse initially, but our results show that over time, anonymity built user trust and led to less misuse. That said, we do recognize that there are use cases where anonymous data collection is not feasible (e.g. [7]) - in such cases, we suggest that to promote user trust, they should be provided full control over data sharing, e.g. users could prefer to keep their data private, or share with immediate colleagues or the entire workplace.

Transparency: Next, we argue that transparency is a very important design principle for long term sustainability of the system. We visualized the results of quantification in real-time on the dashboard and mood lamp, which showed the users that the data is not manipulated on the backend and gave them the confidence in the system. They appreciated that negative quantifications (e.g. bored, stressed, etc.) about the workplace are not hidden by the system and this led to increased user trust.

Inclusion: Finally, we emphasize the importance of Inclusion in designing community-oriented systems. The inclusiveness and democratic nature of publicly placed tablets ensured that **any** employee could interact with them, and let his/her opinion count. If we had deployed the Quantified Workplacesystem through a personal mobile application, this sense of inclusion might not be so prominent as many of the users would hesitate to engage due to privacy concerns, which in turn would have reduced the trust in outputs of the system.

CONCLUDING REMARKS

This paper aims to explore the space of workplace quantification. Through the deployment of a prototype Quantified Workplace system in two European offices of a research organization, we found that user engagement with the system was initially driven by community behavior, and over time it translated into a *tiny habit* due to the participatory aspects of the system and opportune placement of input terminals. Users showed a preference towards quantification of those metrics which are beyond human sensing, also stressed the need to focus on *actionable quantifications*. While the idea of a quantification system at workplace may strike as a *big brother* to some people, we found that if designed in the right way with trust and transparency through anonymous data collection and real time visualization, such a system may have wide acceptance among employees. Our results and proposed design implications could drive future research in the domain of workplace quantification, and also assist UbiComp practitioners aiming to design such systems.

Certainly, the results presented here must be interpreted in the context of the culture in which they were collected. We expect our results to be most appropriate for designers of future workplace technology in Europe or countries with similar cultures and levels of technology adoption.

Future research could measure the impact of cultural diversity on user perceptions towards workplace quantification. An exploration on how to systematically incorporate *Tiny Habits* in the design of Quantified Workplace systems could also be a fascinating topic for future work. From a visualization perspective, use of other kinds of ambient displays [31] can be explored for visualizing quantified workplace metrics. While our work was focused primarily on quantification design, researchers should also investigate how to generate and present actionable insights from the quantification to users in a workplace.

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