Co-constructing Stories Based on Users Lived Experiences to Investigate Visualization Design for Collective Stress Management

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ABSTRACT

Collective stress is the stress within a group or an organization. It affects individuals' well-being and group productivity. HCI research has started exploring collective stress visualization to facilitate group awareness and collective coping via testing prototypes in controlled settings. However, an in-depth understanding of users' needs and envisaged scenarios based on their authentic experiences are still lacking. In this study, we utilized a participatory approach called co-constructing stories to investigate how a collective stress visualization would be used in office workers' authentic workday routines. We constructed use case stories with a group of office workers separately based on their personal lived experiences, using a design probe called AffectiveGarden. Our results categorized six clusters of benefits for collective coping through visualization and their implications for future design practice.

CCS CONCEPTS

• **Human-centered computing** → *Information visualization.*

KEYWORDS

co-constructing stories, participatory design, collective stress, visualization design, personal informatics.

1 INTRODUCTION

Collective stress exists when the "members of a particular organizational culture as a group perceive a certain event as stressful" [26]. Excessive stress in the workplace affects the individual's psychological and physical health [24], reduces working performances, and leads to poor communication and increased conflict [34, 40]. Collective stress is eager to be solved both for individuals and for groups of people in the organization. Coping with stress should involve the interpersonal social facets because it is not just a process inside the individual, but often "takes place in dialogue with others" [22]. Moreover, social coping is proved to be more efficient in reducing employee stress than coping individually [40]. Hence, previous social-psychological studies implied the need for developing group intervention tools to facilitate social coping with stress.

With the aid of Human-Computer Interaction (HCI) approaches, users could be provided with actionable, data-driven self-insight
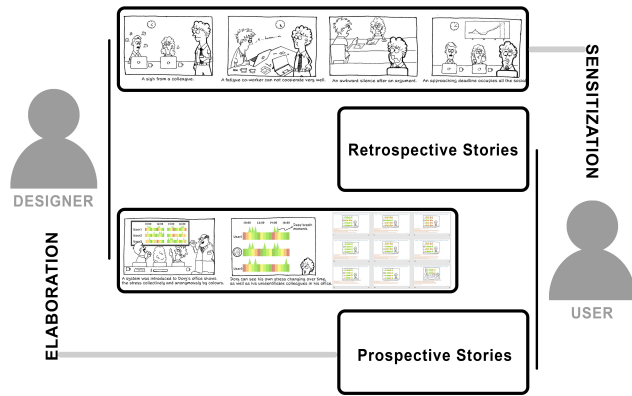
Figure 1: Co-constructing stories contain two phases: sensitization and elaboration [10]. We use storyboards to evoke the user's past memories and introduce AffectiveGarden as an envisioned future to elicit feedback.

to help them optimize their behavioral patterns and thereby improve their well-being [21, 30, 46]. Current HCI approaches, such as biofeedback interventions [51] and personal informatics (PI) systems [1, 28] have been widely applied in stress management for individuals. Meanwhile, a few works began to use PI collectively to raise awareness of collective stress. For example, [50] adopted PI systems to anonymously visualize stress-related physiological information for a group of office workers in order to raise awareness, facilitate reflection, and stimulate stress-coping action. Such systems increased office workers' individual reflection as well as the social reflection on stress status, and it could trigger stress-coping action (e.g., taking deep breathing exercises) when office workers related their subjective stress to the stress-related data (e.g., Heart Rate Variability) visualization. However, such cases of short-term user tests in controlled settings can be limited in gaining in-depth, authentic stories about how such a system would be used in users' naturalistic settings. And these stories are crucial input information for future designers.

To further explore our research questions: *(1) how a collective stress visualization could impact collective stress management;* and *(2) the motivating factors for sharing stress information as well as to whom people would like to share (and why)*, we adopted a participatory design approach in order to gather in-depth understandings to inform future design practice of collective stress visualization. Specifically, we utilized the co-constructing stories method [10] to elicit in-depth user responses and envisions based on their lived experiences in workday routines. First, we made prompt narratives for office workers to relate to their past experiences with collective stress and trigger them to articulate their expectations on how collective stress visualization would be implemented in their real life. Then, we introduced a design concept (AffectiveGarden) as an anticipated future to evaluate fictional scenarios based on their own context (see Figure 1). To adequately sensitize participants about various types of group performances, we showed several narrative storyboards with different group performances. In the end, we conducted in-depth interviews separately with 12 office workers

from different professions, and 771-minute audio recordings were transcribed and analyzed using deductive thematic analysis [7].

The results yielded a rich categorization of insights that users expect to gain from the visualization. Other than the provided information (i.e., my own stress status, others' stress status, collective stress status), participants would also gain insights from social comparisons, combined with observations on-the-spot, and interpretations of how they influence each other. We concluded six preferred design qualities of collective stress visualization systems: *reflection and reasoning, self regulation, empathic concerns, reciprocal help, constructive conversations, collective coping measures*. The results also indicated the factors that may engage office workers to share their stress data as well as the roles in workplaces they would like to share with. At last, we surfaced users' concerns and possible negative impacts the system might be brought in practical use. As a result, this study reveals the potential opportunities for collective stress visualizations via co-constructed authentic usage scenarios, which translate users' needs and desires into design implications for future research and practice.

2 RELATED WORK

2.1 HCI for Stress Management

Stress management is a process from recognizing the stressors to taking actions to cope with them. Aligned with the transtheoretical model (TTM) of health behavior change [37], HCI researchers developed systems to facilitate this process. Stress management in HCI often relies on biofeedback systems and Personal informatics (PI) systems to enable an individual to be aware of his/her physiological activities for self-insight and self-regulation [8]. Physiological stress often uses HRV (Heart Rate Variability) as one of its parameters [13, 20, 44]. HRV can be collected through wearable sensing devices and then get processed and presented to the users through visual [14, 18], auditory [2], and tactile [47] modalities for relaxation training and stress management. For example, breathing-based biofeedback systems guide users to make six-per-minute slow breathing patterns that are proven to be effective in elevating HRV and mediating physiological stress [9, 17].

2.2 Collective Stress Interventions

With the existing theories [43] in organizational psychology and sociology, related literature views stress as a cultural phenomenon that is distributed socially [23]. And researchers increasingly place emphasis on "the collective nature of stress experiences and coping" from an integrated view [26]. Current research points out the need to cope with stress beyond the individuals and explore stress management in teams and organizations, because social coping is more efficient in reducing employees' stress [40]. Interventions on collective stress are mainly sporadically reported in the social psychology field [15, 26, 40], which implied the unaddressed opportunity for HCI research to develop tools to facilitate collective coping.

HCI interventions for stress management are mainly designed for individual users [25, 41]. Since social influences are considered to be a significant positive factor in promoting healthy behavior change, more and more self-revelation systems start to incorporate social features [29, 45, 49]. For example, Miro [3] visualized the office's emotional climate through a dynamic public painting. It

probed into visualizing affective information in a social context for drawing wider consciousness. But Miro's ambiguous representation obstructed audiences from understanding the information. MindForecaster [28] was designed as a calendar-mediated stress anticipation application that allowed users to expect stressful events in advance and to generate plans to mitigate the stress. The "peer" mode of MindFocaster allowed users to see stress interventions shared by fellow participants. However, the user had to enter the events and assess his/her stress levels repeatedly for data collection. In another project, AffectiveWall [50] was developed as a shared visualization that shows office workers' physiological stress indices (HRV data) anonymously in the social context to raise awareness of organizational stress. It increased group members' individual- and social-reflections that could stimulate collective stress regulation, which is valuable for further exploration. However, short-term deployment can be limited in gathering in-depth, authentic stories about how such a system would be used in naturalistic situations, and what the users' latent needs and expectations are. Those stories are essential contextual information for informing future designs.

3 RESEARCH PROBE: THE AFFECTIVEGARDEN SYSTEM

AffectiveGarden is an ambient stress-related informatics system that shows office workers their physiological stress-related signals and deep breathing moments in real-time anonymously on a shared display in the office. Since physiological stress often uses HRV as one of its parameters [13, 20, 44], our design probe collects the group's HRV to visualize them in an intuitive way to facilitate group reflection on collective stress. Group members' physiological stress (HRV index) is collected and analyzed individually through a wearable sensor and visualized with colored bars. Stress is mapped to a withering color (orange), and relaxation is mapped to a thriving color (green) (Figure 2). Deep breathing can be detected through the embedded accelerometer [19]. When the system spots a continuous deep breathing pattern from the user, grass will sprout at that moment on his (her) bar as trophies toward stress management (Figure 2). Office workers can see their stress changing over time, as well as that of their unidentifiable colleagues. Our previous study deployed the AffectiveGarden system to understand how group workers reflect on their daily organization stress by deploying the shared, anonymous heart-rate variability data visualization for a week with six groups of office workers in their workspace. The initial results showed the group of users took the deployed AffectiveGarden system as a vehicle to share their awareness and intervention with their peers. The short-term deployment indicated that the presented system was able to engage its users to make meaningful reflections related to the stressful moments they have in their daily activities.

To further explore in-depth, authentic stories based on office workers' lived experiences to inform future design, in this study, AffectiveGarden was presented as a probe to evoke office workers' contextualized envisions based on their lived experiences, using co-constructing stories [10]. We made storyboards to present the AffectiveGarden as an open-ended design concept instead of a finished prototype to stimulate users' imaginations and envisions. In this way, users can freely express their latent desires and tacit needs
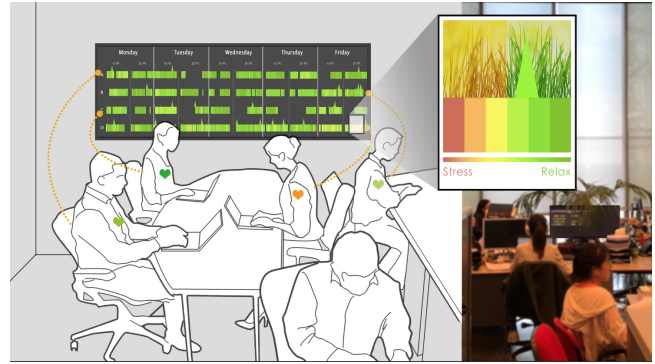
Figure 2: The image shows the use scenario of the shared, anonymous HRV data visualization. From our previous approach, each office worker's physiological stress-related data was collected in real-time and was mapped to colored bars anonymously through a shared display. They can notice their stress changing over time in an ambient way during their everyday work.

by participating in constructing the stories [12] of use scenarios based on their past experiences.

3.1 Participants

In total, 12 office workers (7 females, 5 males) aged from 25 to 54 years old (M = 31.42, SD = 7.98) from different professions were recruited. The demographic information of participants can be seen in Table 1. All participants were: 1) healthy adults; 2) employees who share an office with 3-15 co-workers; 3) from an occupation that involves collective activities; 4) not under-recovery of burnout and did not have a burnout history; 5) fluent in the English language. Participants were recruited using snowball sampling [36]: a few individuals who meet the eligibility criteria were selected initially, and they were asked to help us recruit other potentially eligible participants [11]. But they were not from the same organization. Then we made appointments with the potential participants to confirm whether they were qualified candidates for participating in the study. We estimated the sample size to be from 10 to 20, which should be a suitable range to gather rich and in-depth qualitative insights, and meanwhile avoid excessively repetitive responses or over-saturated data.

The study involved users' envision of how they would experience such a system in their real-life workplace, which may risk in triggering their stressed past experiences. To avoid burnout or causing unwanted feelings, users were informed in the consent form that they could stop the participation at any time, and they could withdraw the permission to use their data under any condition. The study was approved by an institutional Ethical Review Board (ERB) and compensated each participant with a 5-Euro voucher.

3.2 Co-constructing Stories

Co-constructing stories is a participatory design technique to elicit users' in-depth feedback and suggestions about the design concept [10]. It is based on the assumption that "users can make better

Table 1: Demographic Information of Participants

Age	Gender	Nationality	Occupation
27	Female	Dutch	Office manager
35	Female	Jamaican	English teacher
54	Female	Dutch	Congress organizer & associate manager
27	Female	Dutch	Consultant in education in youth care
29	Male	Indian	Process engineer
35	Female	Jamaican	Content curator
25	Male	Greek	Analyst
27	Female	Dutch	Employee in finance department
28	Male	Australian	Process engineering
29	Male	Indian	Accountant for an IT company
26	Female	Canadian	Secretary
35	Male	Japanese	Sales & product designer

judgments about the future design concepts if they link them to their past experiences" [10]. Co-constructing stories method contains two phases: sensitizing users' past memories on the topic of interest and elaborating the design scenarios to evoke their expectations and needs for future applications. The whole process is established through collaborative storytelling, and the designer sets the stage for dialogue.
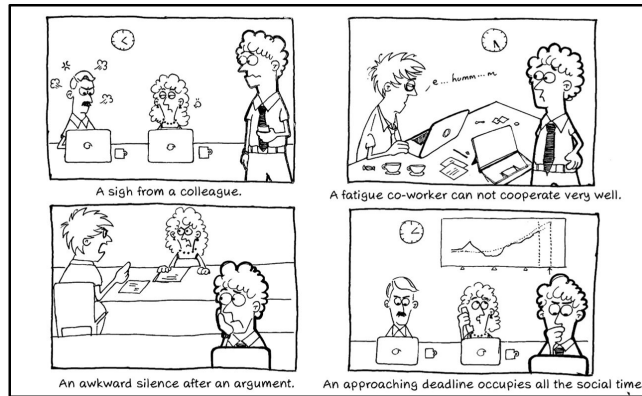

Figure 3: Part 1 of a fictional story was told by the designer in order to evoke participants' past experiences on collective stress.

3.2.1 Sensitization Phase. In the *sensitization* phase, we started with a fictional story through sketching (Figure 3) to introduce a couple of collective stress scenarios in order to evoke participant's past experiences on collective stress. The designer started the narrative by presenting four typical social stressors that occurred to the main character Dory: colleagues sigh a lot, colleagues cannot cooperate very well, arguments make the atmosphere very awkward, and approaching deadlines occupies office workers' social time. The story ended by asking the participant whether they had been in similar situations and which aspects of the story made the situation recognizable for them to relate to their past experiences. Afterward, each participant will be asked to recall the three most salient times that (s)he had experienced in real life and how the collective stress

situation continued in their case. This way, throughout the sensitization phase, we were able to obtain a deeper understanding of the participants' context of use.

3.2.2 Expectation Phase. Following the aforementioned story, we set an additional phase between sensitization and elaboration with questions regarding office workers' expectations. We illustrated example solutions to collective stress to explore participants' expectations of visual expressions (Figure 4). By restricting the design to visual solutions, we are able to invite participants to co-design based on existing knowledge of visual explorations in the field and meanwhile release participants' pressure to come up with brand new solutions in a short time. We named this additional stage as *expectation* phase. We continued Dory's story and illustrated how the human body reacted to stress, and how stress can be accurately measured, and ended up with collective stress visualization that can help. Then we asked participants what they expected to see in the visualization and let them co-design scenarios on how such visualization could help group members manage stress.
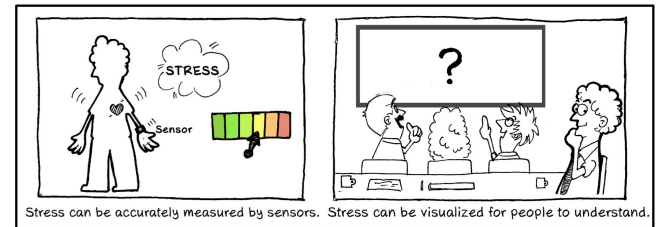
Figure 4: Part 2 of the story was brought to understand participants' expectations on the collective stress visualization design.
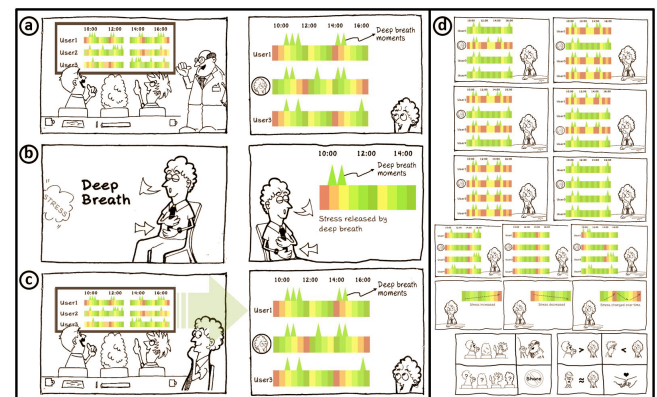
Figure 5: Part 3 of the story illustrated an anticipated future to apply AffectiveGarden in an office scenario. The participants were engaged in finishing the story according to their own needs, dreams, and aspirations.

3.2.3 Elaboration Phase. In succession, in the *elaboration* phase, we introduced AffectiveGarden in an envisioned context and illustrated the concept through sketching (Figure 5). Specifically, in the

last part of the story, we first illustrated Dory and his colleagues' scenario in the use of AffectiveGarden in their office (Figure 5a). Then we explained how the AffectiveGarden system worked (Figure 5b) and how Dory and his colleagues interacted with it to cope with collective stress (Figure 5c). After the story ended, we asked the participants to illustrate what they like and dislike about the AffectiveGarden design to elicit their positive and negative feedback. And we asked them to think aloud and envision how the story would be like if the user him(her)self is the main character. What would they do, and what would stop them from coping with stress through interacting with the visualization. And we encouraged participants to link their previously-described past memories with the AffectiveGarden design concept, to let them elaborate on how the design could be adapted or applied in their own context. The situations in that they prefer to use such a system are also collected.

Afterward, to adequately elicit users' feedback about various group performances of the collective stress visualization, we showed the narrative storyboards with different group performances. Various situations were presented, such as the participant was the most stressed one; or the participant was the most relaxed one; or the participant was stressed but not alone; or the participant was in a situation that everyone was stressed, and so on (Figure 5d). The dialogue also included participants' willingness to share their stress information and to whom they would like to share with.

3.3 Analysis

The first author transcribed the interview recordings that covered the whole storytelling session. In total, there were 771 minutes of data from all the participants; each in-depth interview lasted for approximately one hour. As a primary approach in thematic analysis, the deductive (theoretical) thematic analysis uses a 'top-down' way to code qualitative data driven by the researchers' analytic interest [6]. Therefore, to answer our research questions, we conducted a deductive thematic analysis method [7] to identify office workers' contexts, expectations, as well as attitudes on the usage of collective stress visualization design. The process of data analysis followed the six phases in [7]: familiarising with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report.

4 RESULTS

All participants were sensitized to relate their past experiences with the collective stress scenarios, and this led to rich experiential data that helped us understand this design context. Corresponding to the example scenarios provided to them (such as 'arguments with colleagues' or 'the approaching deadline'), the participants were able to recall similar types of scenarios from their own experiences. Furthermore, some participants added examples from new kinds of collective stressors (such as colleagues tapping their feet all the time, or anxiety of others). By analyzing these co-constructed authentic narratives, in this section, we report the findings in regard to our two-fold research questions: (1) how a collective stress visualization could impact collective stress management; and (2) the motivating factors for sharing stress information as well as to

whom people would like to share (and why). At last, we summarized users' concerns in deploying such visualization systems in their workplaces.

4.1 How a Visualization Design Could Impact Collective Stress Management – Summarising Preferred Design Qualities

In this section, we answer this question by summarizing *the types of insights that users might learn from a collective stress visualization* and *what impacts these insights might lead to*. These impacts are then generalized as six preferred design qualities from users' envisioned scenarios for collective stress management: reflection and reasoning, self regulation, empathic concerns, reciprocal help, constructive conversations, and collective coping measures (see Figure 6). Below we will first address the types of insights expected by the users, and then connect these insights to their impacts.

4.1.1 Insights into my own stress status: When they saw their own stress data, the users would tend to reflect on where that stress status came from. And they would try to mitigate their stress status after being aware of it, either by self-regulation or requesting help from others. As reported by P3, if she could see her stress level changing over time, she would firstly reflect on *"what the situations are, and why you are stressed."* And this could make her *"be more relaxed about the situation with stress"* because she will be more aware of what happened and thus have more conscious control over *"what to do with it."* For another example, P4 claimed that with insights into her own stress level, she would *"first try to manage"* by herself before asking for help from others. If the stress status remains after self-regulation, the participants mentioned that they would ask for help from others. For instance, P2 noted, *"I would tell them the challenges that I'm having, and ask for help. Am I wrong? Am I right? What is your advice?"* In sum, these examples indicated that insights into one's own stress status are essential for users to gain an understanding of themselves and to motivate stress-coping activities, including self-regulation or requesting help.

4.1.2 Insights into others' stress status: The participants mentioned that being more aware of their colleagues' stress levels would make them be more considerate and do things differently. And they could have more empathy for colleagues and more willingness to understand others or to offer help. First, the participants said they would like to reflect and speculate on the possible reasons that might cause others' stress levels to rise. P4 compared stress situation to climbing a hill, she noted if she saw her colleague always at the top, she would let him be aware and figure out why: *"Is it work situation or private situation?"* Second, seeing others' stress-related information makes people adjust their behaviors, and do things more thoughtfully according to the current situation, and contributes to a harmonious working environment. For instance, P1 mentioned: *"if I know that you are very stressed that day, then I think OK I will ask my question tomorrow."* Similarly, when recalling an occasion in the past, P5 said that he would have interacted differently if he knew his colleague was undergoing stress: *"...when I have a disagreement. At that point in time, I see that person she is crazy in that time on her stress levels. I would actually never bother her at that time. Maybe I will approach her later when she is less stressed."* Third,

| What can users learn from the visualization | | | What impacts the visualization might have |
Insights	Description	Example quotes	(Preferred design qualities of collective stress visualization)
Insights into my own stress	When users see their own stress, they would look for reasons, regulate by themselves, and ask for help from others.	"why am I stressed, why am I feeling like this, what should I do?" "I can start managing it by myself." "I would tell them the challenges that I'm having, and ask for help."	*Reflection and Reasoning*
Insights into others' stress	When users see others' stress, they would look for reasons, adjust themselves, develop empathic concerns for others, and offer help.	"I would be cautious to other people's...to understand what is that stress coming from." "I will approach her later when she is less stressed." "...that would made me more aware what's happening. I can be more patient, I can be more understanding." "...I will ask my coworkers that is there anything I can do for you, and do you need any help?"	
Insights into collective stress	When users see the collective stress, they would look for reasons, take care of each other, discuss and interpret the stress situation together, and take stress-coping activities together.	"we're all stressed. I probably ask them what's going on, find out what's going on as well." "we have to come together and figure out a way during the all stress." "it can be an opening to talk about it." "why don't we all go for a 10 mins walk to lower our stress level before we go to work."	*Self Regulation*
Comparison between my stress and others' stress	When users compare their own stress with peers, they would look for reasons, ask for help or offer help, and discuss with peers.	"If our team is stressed and the other team is not, it's not fair, I would wonder why they are relaxed and we are stressing out." "I'm gonna ask have you ever been this situation before? What did you do?" "Is that we are more hardworking than they are, or is it about they are more efficient and finish task better."	*Empathic Concerns*
Inferences made combining the visualization and observations on-the-spot	When users combining the visualization and observations on-the-spot, they would look for reasons, adjust themselves, develop empathic concerns for others, ask for help or offer help, discuss with peers, and take some collective coping activities.	"what causing my stress, is it related to the job..." "Maybe you were shouting and you were not even aware, pull back a little bit, calmer, and make a respectful approach." "I would be cautious to other people's body language more often, to understand what is that stress coming from." "people in it with you...they are the best ones who can help you while you can help them." "If the other one has the same stressor as you have..you can talk about it, it often helps." "...because you are aware that you are irritable so at least we can take a break."	*Reciprocal Help* *Constructive Conversations*
Interpretations on how we influence each other	When users interpret how they affect each other, they would look for reasons, develop empathic concerns for peers, and collaborate more efficiently in their work.	"you can see how you affect others, and how others affect you." "...what you are doing is causing stress in someone else, the right thing to do is to adjust." "how did that affect your ability to work together. You were working together better when you were stressed...You can perform better on tasks together."	*Collective Coping Measures*

Figure 6: To understand how the collective stress visualization could facilitate collective stress coping, we make connections between *what can users learn from the visualization* and *what impacts the visualization might have*. The six preferred design qualities construct our framework of collective stress intervention design.

seeing others' stress levels leads to empathic concerns with other colleagues which is beneficial in preventing conflicts. For example, P9 indicated that *"other people's stress could be as important as mine."* With the empathic concerns for others, they *"won't fight each other."* And it enabled them to *"first allowing the stress level to be down, and talk in a normal tone."* Fourth, when people notice their colleagues are undergoing stress status, they would be willing to offer help spontaneously. Like P4 reported, she would ask her coworkers if she could do something for them to support their work: *"Probably I will ask my coworkers that 'is there anything I can do for you, and do you need any help?' I have enough space because I'm not stressed, so if I can release stress for someone else by taking something off their work, I will do that."* In sum, insights into others' stress-related status would help people reflect on the reasons, be more considerate, do things differently and support each other.

4.1.3 Insights into collective stress status: Collective stress is the stress status shared by the whole group or the workplace. When

showing collective stress-related data visualization to users, they claimed they would reflect on the reasons from a collective point of view, offer help to each other, discuss the current situation, and initiate collective coping activities (e.g., take a break together). First, seeing the collective stress status triggers users to look for reasons from a collective point of view. For example, P2 stated that seeing collective stress-related information makes group members reflect on themselves and look for reasons together: *"I probably ask them what's going on, find out what's going on as well."* Second, seeing the collective stress-related information could engage reciprocal help. Like P8 stated that if the group is stressed, her colleagues would complain to her and wait for her to report to the boss, because she had the best relationship with the boss: *"They will wait for me to do something. They will complain to me, and I will complain to my boss."* Third, insights into collective stress status encourage constructive conversations. Office workers would get together to interpret the collective status. For example, P4 described that if she and her colleagues could see the collective stress visualization, it would be

easier for them to open up conversations: *"it can be an opening to talk about it."* Similarly, P11 also claimed that knowing collective stress-related information: *"can open up with the communication."* As related to triggering conversation opportunities, knowing collective stress status could also enable self-expressions and reinforce office relationships. P12 addressed that it is challenging in his culture to express oneself to others, the collective visualization *"can be a tool to express ourselves."* In sum, insights into collective stress status would engage reflection and action from the perspective of a group. It would provoke constructive conversations and facilitate reciprocal help.

4.1.4 Comparison between my stress patterns and others' stress patterns: Participants would make comparisons with each other and interpret reasons for similar or different patterns: e.g., why they are more stressed or more relaxed than others. First, interpersonal comparisons engage group members to reflect on and interpret the differences. For example, as P2 envisioned, when her team members were stressed but the other colleagues were not, she would think: *"If our team is stressed and the other team is not, it's not fair, I would wonder why they are relaxed and we are stressing out,"* Second, they would ask for help or offer help based on the comparison. For instance, as P3 stated: *"You feel like some confirmation that you are doing well. Maybe the job is too hard for them. You can help the other stressed ones. Like the other way around, you can ask the relaxed people to help you if they have less work or they know how to relax themselves."* Third, comparisons could engage constructive conversations about interpersonal differences. For instance, P2 would discuss with her stressed teammate that why the other team showed up less stressed than they are: *"is that we are more hardworking than they are, or is about they are more efficient and finish their task better?"* In sum, comparing stress-related data visualizations with peers would make people reflect on and interpret the potential difference, or similar patterns, ask for help or offer help according to the condition, and provokes constructive conversations.

4.1.5 Inferences made combining the visualization and observations on-the-spot: Users would make inferences by combining their observations of real-world situations with the visualization. First, when users connect their current status with what has been shown on the visualization, they would infer the connections. For example, when P3 saw her stress level raising on the visualization, she would relate the visualization with her current working status and reason: *"is it related to the job?"* Second, they would infer how their own behaviors would affect others by connecting the visualization to their social interactions with colleagues. For example, P2 stated that if she could see what she is saying or what she is doing is raising the stress level in someone else, *"the right thing to do is to adjust."* Third, connecting the visualization to on-the-spot situations could develop empathic concerns for others. For instance, P5 claimed that he would be aware of the context and put himself in other people's shoes by connecting other's body language with the visualization: *"I would be cautious to other people's body language more often to understand what is that stress coming from."* Fourth, the contextualized insights smooth the process for users to give and receive help reciprocally. P8 referred her relaxed situation to less workload at hand and noted she would use her spare time to help

with her stressed colleagues: *"I'll see if I can help them."* Fifth, participants claimed they sometimes share similar stressors with their peers at work, which could reflect an 'all stressed' situation on the visualization. Relating these real-life stressors with the performance on the visualization would engage constructive communications that helped with stress management. For example, P3 related the all stressed visualization to a deadline and claimed that talking to each other about similar stressors *"often helps."* Sixth, connections between the visualization and the current situations can facilitate collective coping. P7 compared the office atmosphere to *"lava"*. He would suggest his colleagues *"go have a break"* when he observed people are not busy.

In summary, contextualizing the visualization by on-the-spot observations trigger the most sophisticated reflection and activities. It would engage people to speculate on the reasons, adjust themselves, develop empathic concerns for others, ask for help or offer help, talk to peers and make changes together.

4.1.6 Interpretations on how we influence each other: Users would interpret how they affect others and how others affect them. First, when users interpret the effects of each others' behavior, they would curious about the reasons. For example, P2 explained that the visualization could help her in figuring out *"how you affecting others, how others affecting you...and how it affecting everything."* Second, interpreting on how one might affects others engages the user think twice about his (her) impending behaviors. P11 mentioned that she would think twice that her colleagues *"are not the cause of my stress"* before pouring out her problem to them. Because she thought she should do that *"in situations where it doesn't really affect the colleagues."* Third, noticing how people affecting each other is beneficial for efficient collaborations. Like P2 described, in a project people working together can observe how they affect each other through the visualization: *"You were work together better when you were stressed or do you get more outputs when you were not stressed."* So people can adjust their collaborative strategies to *perform better on tasks together."* In sum, interpreting how colleagues influence each other would help them reflect on the reasons, trigger empathic concerns for peers, and contribute to collective coping activities.

4.2 What Are the Motivating Factors for Sharing Stress-related Information and with Whom People Feel Comfortable to Share?

4.2.1 Motivating factors for sharing stress information: We classified participants' attitudes towards applying the shared collective stress visualization in their office. The results indicated seven major factors that would engage participants to share their stress-related information with others: to help others, to ask for help, to cope with stress together, to share back to whom shared with them, to encourage the group to maintain good performances, to share interesting data and to show off. The detailed descriptions of these motivating factors and quote numbers can be found in Figure 7.

The mostly-mentioned factor is 'help others'. As P8 experienced, her stress status is mainly related to her work. If she has a lower stress level than others, it probably means she has finished her work. So she would take the initiative to ask if she could do something for the stressed colleagues. P5 also indicated that if he is not the

Motiving factors	Description	Num	Example quotes
Help others	Users would share their stress status and coping experiences with peers to offer help.	27	``who is the not-relaxed one and who is the relaxed one. And then maybe try to draw a plan to help people who are not relaxed''(P5); ``when my workload is low I would share, and I would ask if I can do stuff for you''(P8); ``say, look, this helps me, perhaps it could helps you too''(P3); `` it doesn't work for me but maybe can help others''(P12)
Ask for help	Users would share their stress and troubles to ask for help.	24	``I'm gonna ask have you ever been this situation before? What did you do?''(P6)
Cope together	Users would share their stress to find out solutions together.	19	``we are all feel the same, we have a kind of common feelings. We are all in there together. But if it's long-term, we have to find out what is the problem and what we have to do about it''(P4)
Share back	If others share with them, they would like to share back.	11	``When others do, it's easier for you to talk about it as well''(P1)
Encourage maintenance	Users would share to keep the good performance.	5	``for the whole team to celebrate, let's keep it that way''(P7)
Interesting data	Users would share stress with others if the data is interesting.	1	``I would share if the data is interesting''(P10)
Showing off	Users would share to show off.	1	``I'd like to showing off''(P10)

Figure 7: Motivating factors that could engage participants to share their stress.

only relaxed one in the team, he will share with someone who's also relaxed to *"draw a plan to help people who are not relaxed."* The second factor is 'ask for help', as P10 claimed, he would share to ask for help from others: *"If I'm not able to solve a problem. Then I will discuss with them. I would share personal stress, professional stress, something without my control, things you expect it going to work, would trigger me to share. For my career, for my problems, for my KPIs, I would share it."* The third factor in engaging sharing is 'cope together', which often happens when people encounter similar stressful situations. As P4 mentioned, sharing stress with colleagues can have a sense of feeling that they are facing the challenge together, and that she is not alone. And if the stress status didn't go away, they could find solutions together. When other people start sharing, it would also encourage users to share back. Like P4 said, others' sharing would make sharing easier for her, *"I would straightforward to share if someone asks how are you doing. If someone saying something like, you were a little bit down for a few days, OK, all open."* Whereas they would also consider if the audience is trustworthy and helpful, like P6 indicated *"if in the office people are friendly, it's nice to share and talk."* If the overall performance is good, sharing could happen to keep the good performance. As P7's claimed, if the whole group is relaxed, he would yell out to engage colleagues to keep it. P3 also suggest the whole group to *"do something fun when we are all relaxed."* Other factors like *"I would share if the data is interesting"* and *"I'd like to show off"* are also mentioned by P10.

4.2.2 To whom is safe to share stress with: As illustrated in Figure 8, we categorized the workplace roles that office workers feel comfortable sharing their stress-related information with. The most frequently mentioned targets are: their boss, colleagues who have a close relationship with them, and colleagues who have similar age/hierarchy/stress conditions.

Office workers would like to share stress status with their boss mainly because people with a higher hierarchy (e.g., managers, boss, leaders) are responsible for employees' mental well-being and capable of removing the stressors from an organizational level. Like P9 addressed: *"My boss should know what kind of stress I'm going through. He may give me a holiday if necessary."* Sharing with

Who to share with	Num	Example quotes
Boss	9	``That's his profession to be a manager. The system can help him arrange things reasonably''(P7); ``my boss is also my colleague, we always joke and make fun of my boss...you have to make sure the environment is ok, everyone's happy to go to work, wants to work, and doesn't go stressed''(P8)
Colleagues who have a close relationship with me	9	``people who get alone really well, those people I would like to share with them''(P5); ``I would try to approach one with good relationship in the office''(P12)
Colleagues who have similar conditions (age, hierarchy, stress) with me	9	``someone who has same age as me...she would say because you are young or whatever''(P1); ``we all on the same line, on the same level''(P8); ``they are doing the exact same work. Maybe they were in the same position before''(P11); ``someone with similar condition could be more understanding''(P6); ``you can both be angry about the same stuff and complain...you will get the feeling of relieve at the end''(P8); ``Someone they don't impact your day to day work, but works in the same company''(P11)
Colleagues who are not stressed	8	``if you can't manage, you can't help me neither''(P2); ``I prefer not to speak to people who are down, because you would drown into it''(P4); ``share to people has more stressed than you is like you are showing off''(P7); ``if they are relaxed maybe they have some space...they can provide some tips or provide some help''(P12)
Colleagues who are professionals	7	``I would ask for help from some other source in the organization who are formal, and have the non-disclosure agreement''(P6); ``talk to a counselor''(P9)
Colleagues who need help	3	``I would tell who is experiencing stress, I would say like I think you are a little bit stressed. I had it a long time ago and I was doing this and this, and this that helped very well''(P4); ``only somebody who needs help''(P5)
Colleagues who are not the cause of my stress	3	``If I am stressed because of them, I think I'm not going to talk about it''(P1); ``I really would not want to share with them if they are the cause of my stress''(P11)
A general colleague	2	``If you don't know people are stressed, you can't help''(P8)
Colleague who sits close to me	1	``I always talk to the colleague who seats close to my table, I share the most with him because that's the easiest''(P8)

Figure 8: To whom office workers would like to share their stress with and exemplar quotes.

colleagues who have a close relationship with made people feel *"comfortable"* (P4, P7, P11), and they do not need to worry about the data being misused (P3, P6). Sharing with someone with similar conditions would gain more understanding and support. P1 noted she would share her stress-related information with someone of similar age because they would tell her *"because you are young or whatever"*. Their understanding always made her feel better. P8 claimed she would complain to other stressed colleagues, and she could always gain some agreement from them. P11 also mentioned that *"if you know that somebody else has the same stress level as you, you would like to share about it because you are not alone."* Sharing stress-related information with someone who is not stressed, on the one hand, *"it wouldn't make the situation worse"(P4).* On the other hand, people might learn and get help from them because those not-stressed ones are considered to be able to *"manage their stress very well"(P10).* Professional positions in an organization (e.g., psychologist, counselor) are also popular audiences for office workers. Like P6 addressed in the interview, *"I would ask for help from some other source in the organization who are formal, and have the non-disclosure agreement."* Office workers showed their willingness to help by sharing their stress-coping experiences with peers. And some mentioned they are hesitant and refused to share stress information directly with someone who is causing their stress. For example, P11 noted she knew sharing could fix problems and make people regulate their own behavior, but she chooses not to share to avoid awkward situations: *"I really would not want to share with them if they are the cause of my stress...I feel that I would not really be open to share that with them, but it's probably good to share with them. So they can fix it."* Share stress to a general colleague (P7, P8) and to whom sit closer (P8) are also mentioned. Quote numbers and other example quotes are listed in Figure 8.

4.3 Remaining Concerns about the Collective Stress Visualization

There remain concerns about the collective use of collective stress visualization. Five participants were concerned that people might interpret the relaxation on the visualization wrongly (P3, P6, P7, P10, P12). For example, P3 and P7 worried her stress data could get finger-pointing: *"I would be scared because maybe you are lazy, that's why you are not stressed. I'm afraid they will perceive like that"(P7)*. And P6 is concerned if people would use her data against her: *"Like, hey, you are stressed, you were stressed at this point, that's why you don't deliver"(P6)*. Four people (P4, P7, P8, P10) worried that the sharing of personal stress might bother others: *"I don't like to burden all the people with my problems"(P8)*. Three participants (P6, P8, P11) mentioned the imbalanced power to use such systems in practice. Like P11 said, people who are in a position of power may not care, but people in a lower position might don't want others to see their stress. Moreover, two participants (P6, P8) mentioned that even though the visualization is anonymized, they still have concerns about getting recognized in using it in a real-life context. For instance, *"Even though it's anonymous, It's easy to be recognized based on the human reaction if you are in the same physical space"(P6)*. P6 and P8 claimed that stress is quite intimate information to share with colleagues. P1 and P3 explained that they wouldn't want others to know when they were undergoing stress because that may be made them look weak. For instance, P1 stated *"When I stressed I wouldn't tell people 'oh I'm stressed', I would say 'oh I'm fine'"*. Last but not least, P2 and P12 mentioned the visualization can be more aesthetically appealing.

In summary, office workers were motivated to connect their collective stress experiences through this co-constructing stories study. AffectiveGarden performed as a design probe to provoke authentic synthesized use scenarios of a collective stress visualization. Throughout the reflective storytelling session, we identified six design qualities that users preferred to have in collective stress visualization systems: reflection and reasoning, self regulation, empathic concerns, reciprocal help, constructive conversations, and collective coping measures. We further concluded the top motivating factors for sharing stress data (e.g., for reciprocal help) and summarized the workplace roles that users would like to share their stress information with. At last, we gathered participants' concerns to deploy such collective stress visualization in their workplaces.

5 DISCUSSION

In this section, we related our findings and proposed several design guidelines in order to guide future stress-coping intervention design from a social perspective.

5.1 System Design Should Support Users' Further Interpretations of the Displayed Information.

According to our findings, other than the three types of insights provided immediately by the system (insights into my stress status, others' stress status, collective stress status), participants also gained insights from further interpretations. That is, they get insights from comparing their stress visualization patterns with others, from combining the visualization and observations on-the-spot, and from interpreting how their stress-status affects each other. Therefore, designers should support or leave sufficient space for users' interpretations building upon the provided information. Here we give an example to facilitate contextualized insights by making the connections between real-life situations with the visualization.

In our findings, participants would combine the visualization and their real-life observations to understand certain circumstances. It is in line with Li et al.'s statements that users would look for contextual information that could help them explain what was happening to them [31]. These findings implied that system designers could construct connections between the information visualization and real-life content to augment users' experiences, contextualize their reflections, and help them explain what was happening. For example, when there is an upcoming deadline, designers could design event-driven connections through visualization. The characters and background in the visualization can be designed differently from the common days that fit into this specific busy period to reinforce users' connections with the real world. One example is Miro [4], an ambiguous information visualization system installed in an office building to provide the overall emotional climate to office workers. Designers mapped sociability to the clustering of the representative characters, which incited discussions among users and developed a contextualized emotional climate expression [5].

5.2 Aiming for Reciprocal Help Instead of Peer Competition to Motivate Stress Sharing

Interestingly, we found the top motivating factors of sharing stress-related information with others are 'help others' and 'ask for help'. Unlike other collective PI systems (e.g., sharing steps or other physical activities to create positive peer competition), in stress sharing context, the focusing point to motivate sharing should be to support reciprocal help in a secure and harmonious atmosphere. When users saw their colleagues getting stressed or they have some successful or failed stress-coping experiences to tell, they would like to share in order to help others. And users would ask for help if they need it and feel secure to do so. Collective coping activities and reciprocal help would happen when users noticed the overall performance of the group is below their expectations. Therefore, system designers could use these patterns to design customized cues to engage reciprocal help in different contexts. For example, when the system sensed userA is the most stressed individual in the group for a certain period of time, it could push a private notification to userA to suggest him approach his colleague userB, who is currently not occupied with his work, to pour out his troubles. Mechanisms to find a stress coping network around an individual that facilitates social coping can be referred to Rabbi et al.'s research [38]. Remarkably, the presence of the 'helping out' process should be designed as aesthetically pleasing. As suggested by two of our participants (P2, P12), the visualization could be designed more aesthetically appealing. P4 compared experiencing stress status to climbing a hill, *"You know going on the hill, the stress helps you, but up on the hill you should be careful don't fall."* It inspires future designers to

design metaphors to make the reciprocal help process more engaging. For example, the 'helping out' process can be visualized as userB's character 'give a hand' to userA's while climbing the hill. More positive metaphoric ideas can be inspired by Biophilia design [27, 48]. To further engage reciprocal help, designers could further develop rewarding mechanisms. For example, helpers can collect rewards for helping others with their stress-related situations, which can be further linked to bonuses for contributing to a healthy workplace environment. With this kind of pleasing and engaging collective coping mechanism, reciprocal help can be supported, sharing might happen more fluently and naturally, and users might feel more secure and beneficial to share their stress status in the workplace. Future design can test such ideas in situ to evaluate the mechanisms regarding the existing interpersonal dynamics in an office space.

5.3 Collective Stress Visualization Should Support Nuanced Configurations for Selective Sharing and Anonymity.

According to our results, we noticed that users have different requirements for anonymity. Some participants expect the visualization to be not anonymous so that they know who needs help. Whereas, some participants preferred high anonymity because they were concerned with misinterpretations from others. System designers should consider how to balance users' diverse requirements on data anonymity, and provide nuanced configurations for different workplaces. For instance, the system could support users to make choices flexibly. For instance, users can choose how he (she) expects his (her) feedback to be. One could choose to visualize his (her) stress-related data as an anonymous individual or to put his (her) name on it and openly share it with peers. For users who are worried about physically being in the same space would cause disclosure, designers can provide options to suggest them join as part of a unit. The unit is constructed by the user him (her)self through inviting his (her) trusted colleagues. Then the feedback would show an aggregated outcome of the unit as a group instead of an individual. He (she) can interpret the results with whom they trusted and help each other obtain information reciprocally. If one does not want to share with anyone, designers can complicate the mechanisms to maintain anonymity, such as involving options of fake roles. One can join in visualizing his (her) stress data combined with the fake roles as a unit. Other audiences would see a unit performance, which is actually the stress status from that anonymous individual who doesn't want to share. In this way, anonymity can be sustained, and the perceived collective stress data remains accurate because no fake data are invited in this process. However, as trade-off, users might get confused about the total participants' number in the visualization. Future system designers can explore more solutions to support selective or partially anonymous sharing.

5.4 From Collective Stress Mitigation to Collective Stress Prevention

According to our results, many people claimed that their collective stress situation could have been mitigated if they had this system in their workday context because they would have more understanding of what is going on inside the workplace and be more

thoughtful about their interactions with others. Moreover, office workers indicated that the system could help them identify when the opportune time for collaboration is and when to pull back, which inspires us to design for collective stress prevention. Other than only providing the stress information and letting users figure out the current situations, the system can also provide cues to 'suggest collaborations' or 'avoid conflicts'. And it may also suggest collective activities such as 'coffee break' or 'microbreaks' [39] as stress prevention approaches. In this way, users are able to 'read' the collective atmosphere more easily and act on it with less time spent interpretation and making decisions. Noticeably, system designers should be cautious about the presentation form as well as the notification time. The opportune stress intervention delivery time can be predicted by multiple data, such as computer usage, intervention history, and activities [42]. Designers can refer to this data [42] to facilitate them in determining a good timing of feedback.

5.5 Designing Actionable Suggestions That Have Flexible Options and Clear Progress Indicators, and Can Fit into the Context

Our results suggest that users would try out the suggested stress-coping actions from the AffectiveGarden system. Meanwhile, they would also do other things they either tried before or believe it works from their previous stress-coping experiences. Therefore, intervention design should leave options open [31], engaging users to try out new things and also allowing them to practice techniques they are already familiar with to cope with stress status.

Many participants implied the need to take stress level trajectories under control. For example, P1 claimed she would not want to finish the whole day's work with a red performance before leaving. Therefore, system designers should provide achievable suggestions that could satisfy users' self-efficacy to act on it and see the progress of their efforts. Such as in the Fish'n'Steps project, users can take steps and observe their achievements right away from a progress bar [32]. By hinting to users that they can make a difference toward a healthy goal by doing a specific activity, the system can expect users to practice the target behavior in future applications.

Our findings also indicated that users might refuse to do the suggested stress-coping action because they consider it cannot fit into their context in terms of time and place. For example, P4 claimed she wouldn't take deep breathing suggested by the system because *"It's just not my thing. Of course, it helps a bit. I just know it's not the thing for me."* Whereas she would take other coping strategies *"I would definitely talk with someone about it...Someone who can relate to you in this situation, who can talk along with you, that would be enough."* Therefore, the system design should provide flexible and smart stress-coping suggestions, which are context-fit. For example, the system can be developed to learn each user's preference for stress-coping techniques that they consider helpful, and customize the interventions accordingly for the users.

5.6 Considering Interpersonal Dynamics and Asymmetrical Nature in Workplaces

Some of our participants mentioned workplace hierarchy might influence people's experiences in using AffectiveGarden, which forced us to think about the use of such systems in practice. On

a practical level, the introduction of such technology implies constant or regular tracking of office workers' physiological data. If such a stress-sensing technology is allowed, its adoption should be voluntary rather than enforced. Regarding privacy, all individuals involved in the data collection process should be properly informed. The users should not only be aware of what data is being collected and for what purposes but also be notified of where this data is being sent. To prevent users from feeling stressed about exposing their data to others, providing users with the ability to control the timing of personal data transmission [16] and revealing less personal information in the visualization [33] can help alleviate privacy concerns in a social biofeedback context [35].

Our current system focuses on self-regulation and local management of stress. Yet workplace relationships are defined by law as asymmetrical (i.e., some people decide and others have to comply). Locating the source of stress in the individual worker puts the spotlight on workers' responsibility for the stress rather than on larger structures and chains of responsibility. However, self-related data plays an irreplaceable role in the reflection in a collective stress coping context [50]. Future designers could handle this conflict by changing the permission to access stress data for different stakeholders. For instance, workers can access their detailed stress data on their personal devices, working groups can access an aggregated group performance on a shared display, and external actors who have the power to enforce changes in companies can access unidentified stress data from each working unit (e.g., a department).

6 LIMITATIONS AND FUTURE WORK

This research remains an initial step toward stress management at work from a social perspective. The findings are based on assumptions rather than real experiences with using AffectiveGarden system. Therefore, the broader negative impacts of tracking and sharing personal data might get underestimated. Our current findings do not necessarily suggest that deploying such a system would always result in a positive direction. Nonetheless, we have identified ways to inform future system design to mitigate possible negative impacts.

We interviewed office workers from different organizations to obtain representative insights from various working relationships and environments. The intention was to encourage participants to express their opinions freely during the interview without worrying about information disclosure. However, their opinions on the working hierarchy and environment may not have been fully captured. Future research can explore interpersonal dynamics through group sessions within the same organization to generate interesting insights and to better serve the goal of collective stress coping. Future work in this domain could follow our design guidelines, deploy the system in the wild with colleagues from the same office, and evaluate users' experiences as a unit. It could reveal insights that might not be easily identified in a one-one session.

Workplace relationships are legally defined as asymmetrical. Using worker data may result in access to their performance and evaluation, and potentially lead to judgment or termination. The role of designers and researchers in such systems that may be misused or transformed into surveillance or punishment tools also requires further discussion. Future work should consider potential

issues and misuse of such technology and explore the extent to which data tracking can be considered surveillance and how much surveillance of individuals could lead to specific stress.

7 CONCLUSION

This research explored the office workers' collective stress contexts and their perspectives on applying an envisioned collective stress visualization, AffectiveGarden, anonymously in their specific context. We utilized the co-constructing stories approach to understand users' past experiences, collect their expectations on the visualization design, and identify the envisioned applications of AffectiveGarden. Based on the results, we identified six desirable design qualities of collective stress visualization: reflection and reasoning, self regulation, empathic concerns, reciprocal help, constructive conversations, and collective coping measures. Moreover, we identified the factors that could engage stress data sharing as well as the workplace roles people would like to share. We also surfaced users' concerns and possible negative impacts the system might be brought in practical use. With the promising findings of our study, we demonstrate the plausible applications of collective stress visualizations and translate users' needs to design guidelines for future research.

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