VIT.IN: Visualizing Collective Stress with a Dynamic Painting

Danique Stappers and Jun Hu

Department of Industrial Design, Eindhoven University of Technology j.hu@tue.nl

Abstract. Office workers face high working pressure, which could result in chronic stress. These conditions affect their vitality and can lead to health problems and burnout. VIT.IN is a dynamic painting that represents the collective stress level of employees. Based on the intensity and duration of stress, the dynamic painting will partially morph towards a more stressed or relaxed visualization. In an experiment with several fictive scenarios, behavioral influences were explored related to changes in collective stress. Social connections between colleagues, and general organizational and social values seemed important behavioral influences. Next to this, ethical boundaries were identified for real-life application. Further investigation of these behavioral influences can unveil new triggers, aimed at encouraging healthier behavior amongst the working community.

Keywords: Data visualization \cdot Collective stress \cdot Behavior change \cdot Digital art.

1 Introduction

In 2019, 1.3 million Dutch employees faced burnout symptoms due to too high working pressure. This raised the absenteeism costs to approximately 3.1 billion euros, which makes the situation problematic for employers as well [21]. Even though stress is a useful factor in completing tasks efficiently, a high workload often requires high performance, leading to increased stress levels. Especially when stress levels are increased for a longer amount of time, chronic stress can be developed. This leads to serious health problems, such as headaches, insomnia, concentration issues, muscle tension, and eventually burnout when not taken seriously [7]. Therefore, chronic stress prevention is essential for a healthy working community.

The European Union acknowledges the seriousness of work-related stress, demonstrated in the European Framework for Psychological Risk Management (PRIMA-EF) [22]. PRIMA-EF contains guidelines for EU companies defined by the Institute of Work, Health and Organizations in 2008. International recognition of work-related stress has created a well-studied research domain. Lansisalmi et al. (2000) emphasized the importance of investigating collective stress within organizations since it gives a holistic view [6]. However, most current studies

are focused on individual stress. Within design research, investigating collective stress allows for managing and reflecting upon stress by shared data visualizations [23, 26, 24]. Nevertheless, behavioral influences in this direction, have not been investigated sufficiently.

Thus, within this study we have tapped into behavioral influences of collective stress within the field of design research. Office workers were targeted since they often face stress due to high workloads and working pressure, e.g. because of deadlines and time restrictions [8]. The research artefact is a digital collective stress visualization, to elicit behavioral insights in a hypothetical setting. First, we have designed an initial visualization through a co-creation session. Based on the received critique on a design demonstration day, we have derived two new visualizations. By comparing these visuals in a small user study, we have chosen the most empathic and artistic visual, which became the research artefact: VIT.IN (Vitality Insight) (Fig. 4). The following question will be answered through VIT. IN: "How does a dynamic painting, that represents data about collective stress, influence behavior amongst office workers in different fictive scenarios?"

We have used a combination of hypothetical choice experiments with elicitation interviews to answer the research question, while evaluating personality traits and VIT.IN's aesthetic quality quantitatively. With this study, we aimed to contribute to the field of design research by gaining insight into the value of collective stress visualizations among office workers. Investigating this newer domain of collective stress can unveil new triggers for a healthier behavior change. These triggers could be applied in future investigations to create a healthier working community.

2 Related Work

2.1 Visualizing Vitality

The vitality of office workers is a common topic within design research. Elvitigala et al. (2021) designed StressShoe [3], a sensor for measuring work-related stress amongst office workers, which could be attached to their shoes. When stress levels changed, there was a contextual change (desktop background), a message to manage stress (take a break, stretch), or interruptions (change in music). The measured stress was visualized in an app, which was perceived as most helpful for gaining insight into personal stressors. Ren et al. (2021) investigated the value of coping with and reflecting upon stress by mockup app Steadi [15]. Steadi allows for scheduling tasks, recommendation of breaks, and planning optimizations. In a small explorative study, it was found that Steadi helped with decreasing high stress levels amongst intensive tasks. However, a field study was not conducted. Sharmin et al. (2015) found that personal data visualizations allow for the development of individual interventions by stress experts [18].

Stimulight, a physical data visualization, was developed by Brombacher et al. (2019) to investigate the stimulation of physical activity amongst office workers,

whilst tested with students [2]. It facilitated feedback for individual employees and the collective of them. They found by a thematic analysis, that individual data should be accessible since it could otherwise lack meaning for the user. A thematic analysis was also used to investigate the stress levels of aid workers [28], and in another study about break-taking and accompanied social behaviors of office workers [11]. Xue et al. (2017) developed ClockViz [25], a physical data visualization of collective stress amongst office workers. ClockViz was perceived as a valuable information tool. Additionally, Xue et al. (2019) created Affective-Wall [27], an interactive wall that visualizes both individual stress levels and those of the collective. AffectiveWall was deployed in group meetings and helped participants to interpret their stress levels in a better way. Both ClockViz and AffectiveWall demonstrated abstract and creative data visualizations compared to other studies. However, behavioral influences by collective data visualizations were not studied in these two studies.

2.2 Organizational Culture

According to Peters and Weggeman (2013), most European companies use a combination of the Rhineland Model (West-European capitalism) and Anglo-American capitalism [13]. The Rhineland Model has a social-economic focus where political democracy is applied, in order to preserve job security, public education and public healthcare. The Rhineland model has increased in popularity since the economic crisis of 2008, because it is the most economically stable model. This model is in contrast with the Anglo-American Capitalism, which has a purely economic focus on making money; this is not guarded by the government. Another socio-economic model is the Government capitalism, which is meant to provide income for the government, without political democracy [14]. The applied capitalism is reflected within the organizational culture. It determines the values and the ambiance of the work environment, also considering stress management and personal health of employees.

2.3 Behavior Change

Behavioral change theories are often about changing and maintaining a healthier behavior. Examples are the Integrated Behavioral Model (IBM) [10] theory and the Transtheoretical Model (TTM) [5]. IBM emphasizes that the intention a person has to perform a specific behavior is mainly dependent on their attitude, perceived norms, and personal agency. The attitude is influenced by their feelings (experiential attitude) and beliefs (instrumental attitude) associated with performing a behavior. The perceived norm is related to social factors: whether other people expect an individual will perform a certain behavior (injunctive norm), and the tendency of others to perform the behavior themselves (descriptive norm). Personal agency consists of the perceived control one feels related to the specific behavior, as well as to what extent they believe they are competent to perform the behavior (self-efficacy). When using IBM, elicitation interviews

are used to determine behavioral influences such as triggers, constraints, and social aspects [10].

TTM defines stages accompanied with behavior change [5]. In this theory, the processes from pre-contemplation (no intention to change behavior) to contemplation (intention to change behavior sometimes) to preparation (preparing oneself to change behavior) are of relevance. These processes can be influenced by several factors, including consciousness-raising, self-re-evaluation, and environmental re-evaluation. These stages are followed by action and maintenance, to successfully change and sustain the desired behavior.

When evaluating behavioral aspects and stress, more meaningful insights could be gained by including the Big Five Personality traits [12]. These traits can reflect how certain people experience stress, cope with stress and how they will behave in general. They were mentioned within the Five Factor Model (FFM) which distinguishs the following traits: 'Neuroticism', 'Extraversion', 'Openness', 'Agreeableness', and 'Conscientiousness' [9]. Seibt et al. (2005) demonstrated the importance of investigating the relation between personalities and stress amongst office workers and teachers [17]. Additionally, Grant and Langan-Fox (2006) have found that combining the traits is valuable when investigating a stress-related topic, although this is fairly more complex [4].

In summary, prevention of chronic stress is essential to protect the working community. Awareness is raised, but behavioral triggers have remained unexplored in current design research about collective stress. Visualizing collective stress allows for a holistic view of organizational stress, which is most valuable when individuals can retrieve personal data from the visual [2, 25, 27]. Behavioral influences could be investigated by combining the open-ended characteristic of elicitation interviews [10]. Furthermore, it is important to evaluate personalities amongst the Big Five Personality traits within this context [17].

3 Design

3.1 Design Process

Visualizing Ambiances The value of data visualizations has been demonstrated in previous studies about individual and collective stress. Especially the visualizations aiming at collective stress, characterized abstractness and creativity instead of graphs and specific numerical data. We agreed upon the development of an abstract visual based on grounds for novelty. Furthermore, a data visualization hidden in an artwork seemed less ethically concerning, because it does not reveal specific health conditions. This manner of visualizing seemed less serious and therefore a better dialogue enabler, from a first-person perspective [19]. We have executed a co-creation session with 4 participants to investigate individual differences and similarities about the ambiance of colors, shapes, artworks and data visualizations.

Beforehand, we explained the study and the participants signed consent forms regarding ethical considerations. All elements were handed to the participants as visualization cards, each participant was facilitated with the same set of cards. First, the participants had to sort these elements from relaxed to stressed in about 10 minutes. This was followed by a group discussion, in which participants could indicate whether some visuals triggered an ambiance instead of only visualizing it. The participants had a similar opinion about using softer colors for expressing a relaxed ambiance, whereas stronger and brighter colors indicated stress. When stronger colors were combined with softer colors, stress was visualized, but not triggered. One participant envisioned animated effects based on colors and size of the elements within the visual. Bigger, brighter and multicolored elements would transform and move around quicker than smaller, darker and single-colored elements. The slower movement would indicate relaxedness whilst the quick movement could trigger stress. Some participants argued organic shapes to indicate relaxedness because of their 'soft edges'. Other students argued static shapes to be relaxed, because they are 'clear and easy to grasp'. After this first round of sorting the cards, participants were engaged to create their own visualizations for a stressed and relaxed ambiance. Overall results demonstrated 'connectedness' for relaxedness, whereas disconnection was demonstrated for stress (Fig. 1).



Fig. 1. Co-created artwork with on the left a whole (relaxed ambiance) and on the right this gets disconnected and the beats float out of the center (stressed ambiance).

From a theoretical perspective, Aronoff et al. (1988) found in an intercultural study that sharp edges and diagonals were more likely to represent hazards [1]. This third-person perspective enriches the empirical findings. Therefore, we have decided to express relaxedness with organic shapes and stress with increased straight lines and sharper angles. Furthermore, we have conducted knowledge about color combinations to express an ambiance, without triggering it. Additionally, animated effects should have minimized speed to prevent triggering stress. Consequently, we have gained the insight that relaxedness could be seen as a 'whole' in which individuals are connected. In contrast, an increased stress level would disturb this whole by disconnecting from the center.

A Morphing Artwork Based on the takeaways from the co-creation session, we have created a dynamic artwork. We envisioned this artwork to be a dynamic painting, which could be attached to a wall in the office where most employees could see it. The artwork expresses a whole with pastel colors and organic shapes when the collective stress level is low (Fig. 2). When the collective stress level increases, the artwork will morph slowly and express stress by disconnection, the addition of bright and strong colors and sharper shapes. The visualized faces do not represent specific employees, but they represent the average collective stress level. The artwork itself was inspired by line art, which is abstract and often expresses humans. This way, we have used a style that generally represents faces, but also allows for empathizing when the deeper layer of collective stress is known. From a first-person perspective, it gives a feeling of safety that only people involved within the organization understand the deeper layer; whilst it will look like a general artwork for external people.



Fig. 2. First concept: when the collective stress level increases, the artwork will morph slowly and express stress by bright and strong colors and sharper shapes.

This morphing artwork was shown and explained to design students, coaches and professors for a public exhibition. Visitors often misinterpreted the faces as specific persons whilst they represented an average value. Feedback included that this neglection of individual data could cause demotivation to understand or act upon the visual.

Novelty The feedback from the exhibition inspired us to create a new visual, with improved individual involvement. The facial elements of the previous visual were based on a first-person perspective, that human characteristics could assist in empathizing with the design. However, this was not evaluated. Therefore, two different themes of visualizations were created. One theme was based on traditional data visualizations, using a circle as the basis (Fig. 3. The other theme had an artistic focus, inspired by the previous visual with faces (Figure 11.3). Both visuals were evaluated in a user study with 5 participants at the

same time. 4 out of 5 participants, who participated in the previous study as well, were familiar with the collective stress topic. All participants were master students from Industrial Design, Eindhoven University of Technology.



Fig. 3. Sorting experiment, in which the visualization with the faces was chosen as the final design

The participants received 4 cards of both visualization themes in a random order. In about 10 minutes, the participants had to sort the cards from relaxed to stressed per theme. A group discussion followed once all participants had sorted the cards. While all participants argued that the circle theme was easier to grasp, there were differences between participants' orders. In contrast, there were no differences in the sorting order of the facial theme. 2 participants argued that the background of the first circle visualization was too light combined with a thick circle border, this 'emptiness' and 'contrast' triggered stress. The other 3 participants understood their opinion, but experienced multiple colors as more stressful. All participants argued that the background of the first visualization of the facial theme is most relaxed, because of its warm, convenient and comfortable ambiance; without much contrast. One participant held the opinion that the doodle lines of the circles were more stressful than the peaks. Other participants argued that the increased amount of peaks caused asymmetry, thus interpreting more peaks as stressful. After discussing the sorting experiment, we requested the participants to explain differences in interpretation per theme. All participants found the facial theme most personal and emphatic, one participant mentioned: 'It allows me to translate data to a person right away and therefore makes me more conscious of how my colleagues are doing, otherwise I would probably neglect it'. However, personalization was concerning according two participants, one of them stated: 'I would prefer the circles, because these are less personal. Otherwise I am afraid that I get identified and that others will gossip about my stress levels.' The circle theme was most positively evaluated, on grounds of simplicity, colorfulness and craftmanship. The facial theme was evaluated best on diversity, meaning it was original and inventive. Based on this mixed-method experiment, we decided to continue with the facial theme. This theme allowed

for conducting knowledge through a novel data visualization, since we value originality within design research. Furthermore, we believed that the evaluation of this theme would be more interesting. Namely, when we evaluated it with fictional stress-related data, we were enabled to explore behavioral triggers and ethical concerns; without violating ethical regulations.

3.2 VIT.IN

The resulting research artefact VIT.IN (Vitality Insights), aimed at the representation of collective stress. We have created VIT.IN to study the (negative) impact of increased stress levels, it was not a tool for finding the optimal stress level or showcasing the positive effects of stress. Another important note regarding VIT.IN is that this artefact was developed to investigate behavioral triggers related to collective stress visualizations, in a hypothetical setting. It has been evaluated amongst different fictional situations, without using real data or measuring equipment.



Fig. 4. VIT.IN scenarios. On the left, scenario 1: no stress measured. In the middle, scenario 2: some office workers experience an increased stress level. On the right, scenario 3: one colleague disconnects from the whole, due to an endured increased stress level, other colleagues experience an increased stress level.

We thought of combining individual data to create a whole since integrating individual data could create a more meaningful design [2]. We believed in the

value of having a whole, while this principle was evident in the preliminary user studies. Each face within VIT.IN represents an employee, employees are only aware of which face is a representation of themselves, they have no information about their colleagues' data. The background colors demonstrated the amount of stress, whereas the soft pink represented the most relaxed ambiance; as a result of the sorting experiment (Fig. 4). Inspired by both preliminary user studies, a color changed to a stronger color when the stress level increased (Fig. 4). This color change occurred in the background of the face representing an employee who experienced an increased stress level. Next to the height of stress levels, the duration of an increased stress level is important to consider whether someone is suffering from chronic stress [7]. Therefore, the faces floated away from the center once someone experienced stress for a longer amount of time (Fig. 4). This disconnection resulted from both preliminary studies in which disconnection was perceived as a heavier effect than a color change. Therefore, disconnection was applied for serious health situations, whilst a color change represented a less hazardous health situation.

4 Evaluation

We tried to minimize the ethical risks of implementing VIT.IN in a real context, by doing an experiment with hypothetical scenarios, based on fictional data. This allowed us to discover ethical boundaries which are important for future studies on this topic, without violating ethical regulations.

4.1 Participants

Office workers were recruited via personal networks and Instagram. We have executed this study with 6 Dutch participants (Table 1). P2 and P6 had a managing function, whilst P1, P3, P4 and P5 had an executive function.

Details Participant	Gender	Age	Job	Amount of hours per week	Direct Colleagues
1	Male	25	Executive	Full time	2
2	Male	51	Manager	Full time	7
3	Female	52	Executive	28	1, 4 and 2*
4	Female	55	Executive	16-20	4
5	Female	49	Executive	24	4
6	Female	51	Manager	Full time	2-5

Table 1. Partcipants (P3 works at three locations of the same company)

This study was approved by the ethical committee of Eindhoven University of Technology, and we have used informed consent forms to clarify ethical regula-

tions to the participants. Participation in this study was voluntary and without any compensation.

4.2 Material

We have made use of the following material to execute this study.

- Notebook or desktop for displaying VIT.IN.
- Adobe XD: an animation program of Adobe in which we have created VIT.IN.
 VIT.IN is displayed via this program to the participant.
- Printed or digital images of 3 different scenarios of the sketched version of VIT.IN (created in Adobe Fresco, Fig. 4).
- Informed consent form for ethical regulations.
- Notebook, writing down findings.
- Procedure: study protocol and questions for the semi-structured interview.
- Survey Big Five Personality traits by IDRLabs [20].
- In case of online user-study: Microsoft Teams.

4.3 Procedure

The user study was conducted in an environment in which participants felt most comfortable. The study with P1 was conducted online, and the other studies were conducted in a physical home setting. The study started with explaining the procedure and related ethical regulations, which were accepted by all participants via a signed informed consent form.

First, demographic and contextual information of the participants was collected. Such as personal information and whether the participant had experiences with work-related stress, and if it is a topic that could be discussed openly within their organization. Furthermore, the participant had to describe the amount of direct colleagues; in one room, most closely located; and the kind of connections with these colleagues. Then the research artefact VIT.IN was explained by 3 different scenarios of the sketched prototype (Figure 14). We consciously chose to vary between the example and the actual prototype, to activate the participant to interpret the situations themselves, instead of repeating the example. The participants were informed that this study focused on investigating their behavior, related to VIT.IN, whilst this study was not about measuring and collecting real stress data. After the introduction was clear to the participant, the first scenario of VIT.IN was opened in our notebook, on full screen. We have indicated which avatar within VIT.IN represented the participant, whilst they received no information about which avatars represented their colleagues. Furthermore, the participants were informed that the location of their and their colleagues' avatars would change per day for ethical reasons. The situation was sketched to the participant, in which VIT.IN was attached to a wall where most employees could see it. We have emphasized imagining the scenarios in real-life, and answering as honestly as possible. Per scenario the following questions were asked, there were 7 scenarios in total (Fig. 5).



Fig. 5. The seven scenarios which were used for evaluation

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- How would you feel when this scenario occurs at your office?
- Does this depend on the situation, day or time?
- Would you do something with regard to this visual?
- In case of a visual in which the participant experiences stress themselves:
 - If a colleague asks how you're doing, would you answer this honestly?
 - If a colleague asks to take a break would you accept this?
 - If a colleague asks if they can take some work from you, would you accept this?

The amount of questions was not limited to the above, since a semi-structured interview was conducted, based on elicitation interviews [10]. Participants had to explain their answers to the above-stated questions. Furthermore, participants had to elaborate upon their actions, if there were certain conditions under which they performed the mentioned action or not. In situations regarding social interactions, participants had to explain whether the connection between themselves and their colleagues influenced their behavior.

The hypothetical scenario experiment was followed by a short survey about the Big Five Personality traits via Microsoft Forms, with the addition of Dutch translations [20]).

4.4 Data Analysis

All collected information from the semi-structured interviews were carefully documented per participant. We have conducted a thematic analysis as an initial step, to create oversight in the qualitative interview data. We have created codes per kind of action that participants took hypothetically. Behavioral influences were coded as well (Table 2). We perceived an aspect as a behavioral influence when a change in the aspect correlated with a change in the participant's behavior. The codes were revised and combined into themes. We have linked the themes and corresponding codes per scenario, per participant. Eventually, we used these themes to compare how participants acted in a situation and whether this depended on certain social or contextual factors (behavioral influences). Participants will be discussed by 'P' followed by their number. The overall results were eventually analyzed by an expert with a dual background in both psychology and technology.

4.5 Results

Organizational Culture & Expectations All participants indicated that they work in an organization in which topics like well-being and experiences with stress could be discussed openly. P2, P4, P5 and P6 mentioned this open environment several times in multiple scenarios. This open environment was according to these participants a ground for expecting colleagues to be honest about their feelings and have trust in their colleagues, 'they should know that we help each other in hard situations' (P2). Furthermore, P2 and P5 expected all other colleagues to help them, when they experienced stress. P5 indicated



Table 2. Actions participants would perform in a certain fictive scenario and based on a certain type of colleague. The kind of colleagues that the participants have are indicated behind the participant number with the same letter categories.

the following: 'I always take care of how others are feeling, so I expect them to take care of me in return. If they do not notice it, I will react snippy to them till they show interest in me.'. P1 and P4 had no expectations of receiving help in return, but would appreciate this. P6 expected colleagues with a close personal connection to help her in return, help from others was appreciated but not expected. P3 was the only participant who had colleagues with whom she had no connection. She indicated helping colleagues with a personal or normal connection, and also with a distant connection when this person was experiencing a serious stress level. She expected this help in return from the colleagues with a personal and normal connection, it was appreciated when a colleague with a distant connection showed interest. She did not appreciate help or show interest from colleagues with no connection, 'I have nothing to do with these colleagues, so I would prefer them to mind their own business. Furthermore, I would just say that everything is fine if they ask how I am doing, they do not need to know more.' (P3).

Investigate All participants indicated that once there was a change within the visual displayed by VIT.IN, that they would try to investigate which colleague experienced the most stress from colleagues in categories A and B. P3 was the only participant who had experiences with colleagues with whom she had no connection (category D). Only in a situation which a colleague experienced serious stress for a longer time, such as in scenario 3, P3 would check upon colleagues within categories C and D. All participants except P3 would check up on colleagues within category C, but had no experience with colleagues of category

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D. Furthermore, P2, P3, P4, P5 and P6 indicated that they immediately had a colleague in mind, corresponding with an avatar facing the most stress, when scenario 2 and 3 were displayed. In a situation where VIT.IN did not represent the colleague that they first thought of, they would still try to find out who it would be; except for P3.

Involvement The theme 'Involvement' was sub-divided within 'Assistance' and 'Break-taking'. We have used the code assistance for improving task division, either taking tasks from a colleague, dividing the tasks in a better way or prioritizing tasks. Furthermore, the code break-taking is about taking a short break from a work-related task such as, a short walk to the coffee machinery, take a walk outside or have a personal conversation in another room or location. In general, assistance was more frequently accepted and offered than break-taking.

Assistance P4 and P5 both accepted assistance from all colleagues in scenarios 4,5,6 and 7 and offered it to all colleagues in scenarios 2 and 3. P2 differed from P4 and P5 by accepting assistance in scenarios 4,5 and 6, P6 only accepted assistance in scenarios 5 and 6, P6: 'I will not give any of my work to others when I am experiencing stress, even if they emphasize it I will not listen to them.' P1 accepted assistance in scenarios 4, 5 and 6 from a colleague with a personal connection (category A). P1 also offered assistance to a colleague within category A in scenarios 2 and 3. P3 accepted assistance from colleagues within categories A and B in scenarios 4,5 and 6 whilst she would only accept assistance sometimes from a colleague of category C in scenarios 5 and 6. P3 offered assistance to colleagues within categories A and B.

Break-taking P1 would accept a break only from colleagues within category A, when this offer is emphasized. Additionally, P1 would not offer a colleague to take a break when they feel stressed. In contrast, P5 would offer a stressed colleague to take a break, whereas she would not accept this offers herself in any situation, from any colleague. P4 and P6 would both offer all colleagues in scenarios 2 and 3 a break, whereas they would also accept this offer from all colleagues in scenarios 4, 5 and 6. P2 would offer any colleague in scenarios 2 and 3 to take a break, whilst he would accept this offer from any colleague in any scenario, P2: 'I would always accept an offer when colleagues ask me to have a coffee or a walk, also when the visual would not show that I am stressed. I prefer that people share their concerns with me, because they have noticed something and I think there is always an opportunity to learn from that.' P3 would offer colleagues in category A and B to take a break in scenarios 2 and 3. P3 would accept this offer from colleagues in category A and sometimes B in scenarios 4, 5 and 6, and sometimes from category C in scenarios 5 and 6.

Managing Personal Stress P1, P2, P4, P5 and P6 would focus on themselves when they experience stress, P6: 'I will focus more on myself in this situation, I think that that is also the best for the person who is experiencing stress since I will not be able to give good assistance.' P3 would still focus on helping others, when colleagues with a personal connection are feeling stressed. For P4 and P5 it would make a difference if they were the only ones from their colleagues who experienced stress. P4 indicated that it would raise personal doubts, 'I would think that there is something in my personal situation not going well, I would relate this to myself.' P5 indicated that it would feel different in a way of an unfair workload 'I would be frustrated if I am the only one experiencing this high workload and the rest would not help me.' P2 would report the disbalance in workload to other colleagues directly, but would not feel frustrated about this disbalance.

Personality Traits The personality traits showed differences per participant (Fig. 6). P1 and P5 scored relatively high on 'Neuroticism', with a score of 50%. P3, P5 and P6 scored above 50% on openness, whilst P1, P2 and P4 scored below 38%. All participants scored above 75% on Conscientiousness and above 88% on Agreeableness. P2 till P5 scored 88% or higher on extraversion.



Fig. 6. Personality traits of the participants

Expert evaluation According to the expert evaluation, there was little correlation between personality traits and the behavior of participants per scenario. P1 and P5 both had a relatively higher score of the trait Neuroticism than other participants (Fig. 6). Furthermore, P1 would only accept an additional break when this is strongly emphasized by a colleague with a close personal connection, whilst P5 would never accept an additional break. Additionally, both participants indicated that they would work harder when they experienced stress,

instead of taking more rest. Since neuroticism is related to stress management, this personality trait could result in this specific behavior, according to the expert.

5 Discussion

5.1 Challenge & Approach

We have evaluated VIT.IN in different fictive situations, to gain insight in behavioral influences by data visualizations about collective stress. We believe that this creates initial insights for chronic stress prevention amongst office workers.

We have found that the visualized data affected the (fictive) performed behavior of the participant. For some participants, the connection with other colleagues was an important aspect that influenced their behavior (P1, P3, P6). The presence of a personal connection could mean that someone would easily accept assistance or be involved with a colleague's well-being. In contrast, VIT.IN would not function as a dialogue enabler for colleagues who have no connection, since they would not engage in sharing health circumstances (P3). In this situation, the collective data visualization caused discomfort (P3). Furthermore, the values that organizations hold seemed important behavioral influences. Participants who emphasized that they work in an environment where personal well-being is valued, were more open to assisting all other colleagues and accepting this in return from all other colleagues (P2, P4, P5, P6). Lastly, the participants argued that their behavior was based on the visualized data, but it is not determined whether they would act differently without VIT.IN or if their fictive behavior corresponds with their behavior in real life.

5.2 Behavioral Influences

It is more common for a company that holds a Rhineland Model to look after employees' health [13, 14]. All participants described their company as an open environment where personal health and stress could be discussed, which is in line with the Rhineland Model. However, we noted differences between the participants who only discussed this open environment when asked (P1 and P3) and participants who started about this topic themselves (P2,P4,P5 and P6). Namely, P2, P4, P5 and P6 were more involved with the collective of all colleagues instead of focusing on colleagues with most personal connections. Specifically, for P2 and P5 this functioned as a give-and-take situation, they offered help to all colleagues, but they expected their help in return. Other participants expected help from only colleagues with a closer connection, or from no colleagues, but it was appreciated. The only exception to this situation of social involvement is P3, who would not appreciate the involvement of colleagues with whom she has no connection. P3 was the only participant who had experiences with colleagues with whom she had no connection. This resulted in in-depth insights related to ethical and privacy regulations. From one side VIT. IN could assist a manager in these situations, to create a better ambiance between colleagues within an organization. From the other side, using a tool to improve collective well-being would be a paradox when it eventually leads to personal discomfort, isolation and embarrassment (P3). It is hard to determine whether this situation applies to the majority of employees who have no connection with their colleagues, but we have found that this situation is present for at least one employee. Therefore, when designing for the collective, there should be paid attention to individual effects concerning visualizing stress-related data.

5.3 Social Exchange

These kinds of give-and-take relationships were framed in a social exchange model [16]. Social give-and-take is about putting effort into a relationship while expecting this effort from the other in return. Disbalance in equal give-andtake relationships stimulates motivation to restore the balance. Furthermore, Schaufeli (2006) [16] has found that a disbalance in an inequal relationship in a working environment could lead to frustration and stress by a lack of behavioral rewards; which could eventually result in burnout. The correspondence between our findings and the theory of the social exchange model reflects the importance of applying collective stress visualizations, to keep each other in balance. Additionally, this is in line with the perceived norm someone holds concerning their behavior, the injunctive and descriptive norm [10]. The injunctive norm could trigger extra motivation to perform the behavior of being more involved with each other's well-being because it is expected, whilst the descriptive norm would stimulate performing this behavior because the person in question notices others' performing who perform this behavior. People's social behavior is determined by their personality traits, and these traits could also demonstrate insight in how stress is managed [4, 12]. We have found that the relatively higher scores of P1 and P5 in neuroticism and their behavior of rejecting or rarely accepting additional breaks could create a logical connection. Analyzing this psychological data with an expert, gave us the insight that the mentioned connection could direct at not effective coping strategies with stress. However, the sample size and the amount of data are too small to conclude general findings from this information. Furthermore, there were no other valuable links found between personality traits and the fictive performed behavior, which was confirmed by the expert. More valuable results could probably be generated when the sample size is bigger, and when all participants work in the same organization, to limit the effect of differences in environmental factors.

5.4 Limitations

The limitations of our study include that the research artefact, VIT.IN, was partly inspired on user-studies with students. Since students are not the target group, this could be a possible declaration from the results of the visual quality of VIT.IN. Furthermore, we would like to emphasize that the findings of this study could be used as initial points for future work, but should not be generalized.

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Namely, our study was not executed with a representative group of the working community. Additionally, the behavioral influences were evaluated in different fictive scenarios and could vary from behavior in a real setting. Lastly, we did not conduct knowledge about the need or essence of a research artefact such as VIT.IN since we did not execute a separate control experiment to evaluate behavior without a collective data visualization.

5.5 Contribution & Future Work

We have investigated collective stress by a data visualization based on preliminary studies of Brombacher et al. (2019) [2], Xue et al. (2017) [25], Xue et al. (2019) [27]. Our findings are in line with theirs by demonstrating the value of collective stress, we have found that social and organizational values create an environment in which employees look after each other. Additionally, our study has built up on this by exploring these behavioral influences, that play a role in performing or not performing a specific behavior. More generally, these influences should be considered when designing interventions for a collective of employees, while they have an essential impact on the performance of a behavior. Furthermore, implementing collective stress visualizations in the context could raise ethical concerns. We have found that it could also cause discomfort and embarrassment when it involved colleagues who had no connection with each other. Therefore, it is an important note for the future studies, to carefully minimize the risk of participation in in-context studies. Furthermore, we would recommend to investigate collective stress with a control experiment, to evaluate a situation with a collective data visualization and a situation without. This can firstly demonstrate which behavior was actually performed by participants instead of thinking they would do so, and it can show whether there is a difference in behavior when the data visualization is present. Lastly, a more holistic view could be created when the sample size forms a good representation of the working community or at least a department of one company, which was not the case within this study.

6 Conclusion

Chronic stress is a problematic phenomenon within the Dutch working community, which eventually leads to burnout if not taken seriously. Awareness is raised, but behavioral influences should be discovered before current behavior can be changed to a healthier behavior. While investigating collective stress, we have focused on the whole of employees instead of focusing on individuals. This way, collective stress allowed us to include social and organizational factors, which play an important role within organizations and stress management. An experiment with several fictive scenarios was executed by a collective data visualization, VIT.IN. The found behavioral influences were mostly related to social connections between colleagues or expectations about the desired behavior of both organizations and colleagues. We have specifically contributed to the field of collective stress by investigating behavioral influences. We have identified initial influences that play a role in determining one's behavior. These influences need to be known before behavior change can be reached. Furthermore, we have found important ethical boundaries that should be respected. Namely, a collective data visualization could cause discomfort or shame among employees who have colleagues they have no connection with.

Therefore, we encourage future work on collective stress based on our found behavioral influences. Furthermore, we aim to discover other behavioral triggers in real-life settings, while considering the ethical boundaries found in this study. This way, our study could function as an initial point toward a healthier working community through chronic stress prevention.

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