Modern Environmental Science and Engineering (ISSN 2333-2581)
December 2019, Volume 5, No. 12, pp. 1183-1194
Doi: 10.15341/mese(2333-2581)/12.05.2019/013
Academic Star Publishing Company, 2019
www.academicstar.us

Emotional Analogous Data: Interaction in the Work Space

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Abstract: The work environment and its architectural configuration increasingly seeks to give a conscientious response to the needs of its users as the built environment influences the health and well-being of people through biological and psychological aspects. Considering that human beings base their behavior on emotion, it is essential to expand this domain regarding how space controls, steers, or alters one's emotional state and how this interaction affects perceptions of well-being, health, and productivity. This article sets out a case study applied at the offices of ELISAVA Research, Barcelona, which seeks to understand the emotional state of users in terms of space. The participants consisted of four women and two men. The materials and tools used for the study consisted of: an am/pm emotional assessment wall, facial expression stickers for each user related to 5 emotions, and environmental measurement tools. Emotional state measurements were made regularly, when entering and leaving the space. Various changes were also applied, which were identified on the wall, and qualitative perception and productivity tests were applied at the end. This study aims to correlate psychological, environmental, and energy aspects to understand their relationships and, in parallel, to validate new measurement tools. Direct correlations between physical parameters and user perception, such as light, humidity, etc. have been observed in the results as well as others that should continue to be explored, such as energy, comfort, and sociability, among others. In doing so, we aim to offer scientific data that can impact project processes, ergonomics, and design guidelines focused on the holistic well-being of individuals.

Key words: emotion, perception, work spaces, interaction, ergonomics

1. Introduction

1.1 New Paradigms for Work Spaces, Environment, and Well-Being

The work environment and its architectural configuration is seeing innovation in response to new paradigms, needs, and depending on the individuals using these spaces. On the one hand, this is linked to organizational, flexible, and creative work issues, and on the other, to concepts of sustainability beyond ecological and environmental issues, focused on human beings. The sustainable development of individuals is a concept embraced by the Chilean Ergonomics Society, which places humans within this circle. Therein, the physical characteristics of the environment are a fundamental factor to be studied within "human–environment" interaction systems.

The built environment influences the health and well-being of people [1], (through its biological and psychological aspects [2]. Due to this, the concept of "positive" is being advanced, with its roots in what was developed by Desmet (2013) [3] regarding "Positive Design" and which is currently being extrapolated by Oliver Heath (2018) [4] in "Positive Spaces". It proposes reaching a balance between visual attractiveness, purpose, sustainable elements, and knowledge of human behavior and promotes the

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WELL standard as a fundamental element in the use of spaces in terms of well-being and productivity.

The document "How to create + positive spaces", put together by Oliver Heath along with the company Interface, highlights buildings with WELL certification. They show a 30% increase in productivity and a 76% increase in overall employee satisfaction. Moreover, a 12% reduction in energy consumption and a 40% reduction in water use has been seen, making a close relationship between humans and environmental sustainability clearly visible.

1.2 Stimuli, Perception, and Emotion

The stimuli perceived by people who inhabit spaces, on the one hand, are based on the parameters proposed by environmental ergonomics, including: lighting, temperature and relative humidity, surface temperature of the elements, air quality, and noise. On the other hand, they are related to the cognitive area, such as the perception of color and the understanding of visual information. Therefore, architecture, with all these constituent elements, is directly related to the psychological and physiological aspects of human beings, impacting well-being and even health [5]. There are studies that show that biophilia and the addition of natural elements in indoor spaces can lead to positively valued changes in cognition and emotion [6]. Moreover, in an analysis of various studies conducted in relation to biophilia, it has been concluded that indoor plants can provide psychological benefits such as stress reduction and increased pain tolerance [7].

Regarding psychological aspects, it is essential to understand that emotions are intrinsic in this perception process, through an immediate biological response and, subsequently, in the cognitive process. Since human beings have their biological basis in emotions, this is the first response in the perception process. "It is the configuration of emotion that we experience as Homo sapiens that defines our human identity, not our rational behavior" [8].

According to McDougall's instinct theory [9], and because spaces are systems of stimuli that influence emotions, it is important that architects and designers understand that spaces and objects will influence people's moods [5].

Furthermore, regarding unperceived stimuli, there are other factors that can unconsciously influence well-being, such as electromagnetic waves, volatile organic compounds, and others. Studies have shown the positive effects on the well-being and health of people caused by some volatile organic compounds from certain types of wood, such as Japanese cedar (Cryptomeria). Such positive effects aid in physiological relaxation under stressful conditions and are useful for maintaining the balance of the autonomic nervous system. Therefore, they have the potential to prevent mental health disorders, such as sleep disorders, restlessness, and depression [10].

To approach the study of human beings, relating physical and environmental characteristics of the environment - stimuli - and the perception process, it is essential to refer to other disciplines such as psychology, neuroscience, and other more holistic areas. The use of tests and questionnaires makes it possible to reveal what people feel and think. Furthermore, the tools that allow us to evaluate the environment are diverse - some are based on traditional physics to measure basic parameters and others are based on quantum physics and integral sciences to quantify energy aspects of the environment.

This study explores how the environment affects the emotional state of people using a work space, associated with physical and environmental factors and changes made during the exploration period. These modifications respond to the phenomenological principles of biophilia, artificial lighting, and the creation of atmospheres, which, through the human perception process, translate these stimuli into emotional, neurological, cognitive, and behavioral responses, relevant or irrelevant to the activity that is being done.

Moreover, we sought to correlate existing ways to evaluate and measure psychological, environmental, and energy aspects. The aim was to contribute to the processes and to obtain scientific data that can impact project processes, ergonomics, and design guidelines focused on the holistic well-being of humans.

2. Material and Methods

2.1 Method

We carried out a case study based on an exploratory method which combines the evaluation of the environment and the emotional state of people using a work space — the offices at ELISAVA Research — in relation to the changes mentioned above in the objective of this study.

The participants consisted of four women and two men, aged between 23 and 36, with perceptual abilities falling within normal ranges. Participation was voluntary, without financial compensation.

2.2 Tools

To carry out the assessment of the environment, and for the participants, various qualitative and quantitative methods and tools were used. These were based on the assessment of emotions, physical and environmental measurements, a self-reporting test, and the preparation of material for the general lighting involved.

To do so, an am/pm emotional assessment wall was used, with facial expression stickers related to the five basic emotions (Fig. 1): Happiness, Disgust, Fear, Sadness, and Anger. One of the space's vertical walls was made available for this qualitative tool.

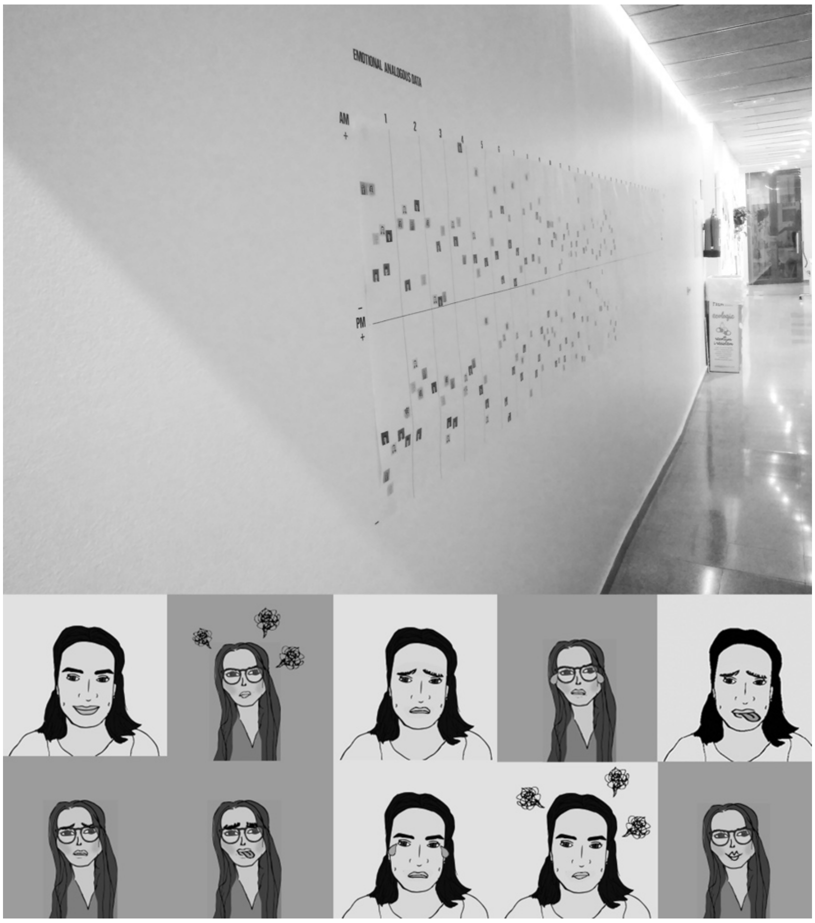

Fig. 1 "Emotional Analogous Data" project wall and example of stickers, five basic emotions per participant. Elisava Research, Barcelona, Spain, 2017-2018.

Also, physical and environmental measurements were developed with quantitative tools having traditional as well as other holistic parameters. The measurements and tools consisted of:

- Temperature - Thermometer
- Relative humidity - Application
- Surface temperature - laser meter
- Lighting - light meter
- Noise - Sound level meter
  Energy environment - GDV, Biowell with the Sputnik accessory (Fig. 2).

Qualitative assessments of the status of each participant and the perception of the environment and its stimuli were done through an online self-reporting test composed of the following indicators:

• States or levels related to: energy, well-being, comfort, awareness, feelings, concentration, comprehension, creativity, and sociability. On a scale of 0 to 5.

• Perception of the environment: lighting, brightness, color, temperature, humidity, ventilation, noise, atmosphere. On a scale of 0 to 5.

• Open question related to the perception of changes made to the space regarding if participants believe that spaces influence them and if so, how - positively or negatively.

• Open space for comments.

Finally, for the general lighting involved, Vitrocuantic® glass pieces with vibrational identity thermomechanical treatment were ordered, with information related to "Mental biological activators", to be applied in the general lighting focal points.

2.3 Place, Characteristics of the Space, and Description of the Changes

The Elisava Research space, located in Barcelona, Spain, consists of a 40 m^2 space (Fig. 3) consisting of seated work spaces with a computer and equipped with artificial lighting at the limit of reaching the recommended ranges [11, 12], minimum natural lighting (Fig. 6), and an air conditioning system.

Fig. 2 GDV, Biowell with the Sputnik accessory.

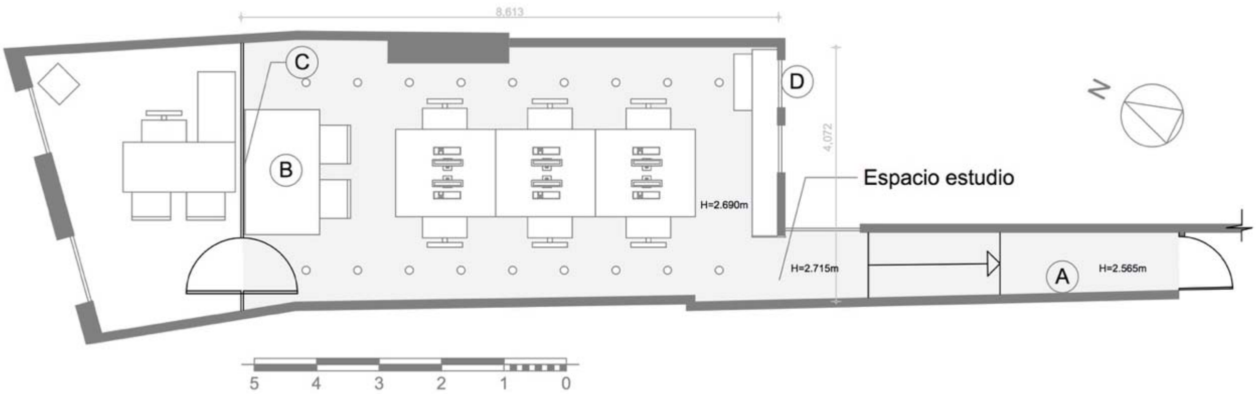

Fig. 3 Layout of the space studied, initial situation: A. Study wall location, B. Meeting table, C. Glazed wall with a screen for video conferences, D. Blocked windows.

Fig. 4 Elisava Research space with changes applied.

1) Placing various plants inside. Benefit: biophilia, a more natural space.
2) Removal of the meeting table and video conference screen. Benefit: space optimization.
3) Placement of new "living room" type furniture — two armchairs and a coffee table. Benefit: creation of a more domestic atmosphere.
4) Incorporation of warm, color temperature, and adjustable focal lighting every other work space. Benefit: quantity and quality of light for reading.
5) Removal of opaque blackboard, separating the management space and the common work space. Benefit: increased natural light.
6) Application of glass with thermomechanical treatment for each light in the space. Benefit: aids concentration.

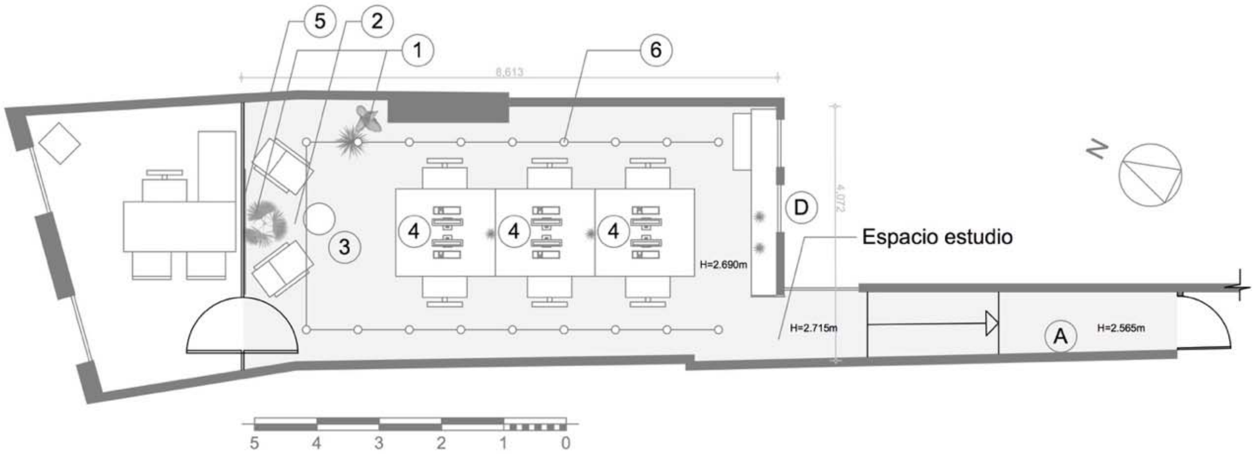

Fig. 5 Layout of the space studied, indication of changes.

2.4 Procedure

Emotional state measurements applied to the wall were done regularly over a total of 150 business days, with no weekends or holidays included. Each day, every participant indicated their emotional state upon entering (am), and the activity was repeated later when leaving (pm). In both cases, the emotion could be placed based on its intensity: a lower intensity was placed towards the bottom. For example, if the emotion was "happiness" and it was located towards the bottom of the am/pm area, this reflected that a participant's state was less happy, while the opposite was true if it was located towards the top.

The physical and environmental measurements were made approximately every two months. In each measurement, the tools described above in point 2.1 were applied, measuring the following: incident light, light reflected off the work surface, temperature and relative humidity, noise level, surface temperature of the elements — table, floor, wall, and ceiling — and energy.

Also, all changes made were placed on the wall on the day they were done.

1. Day 16: Indoor plants
2. Day 22: Removal of meeting table and screen
3. Day 33: New furniture
4. Day 37: Focal Lighting
5. Day 44: Removal of opaque blackboard
6. Day 126: Glass with thermomechanical treatment, one for each light (Fig. 6).

Finally, through an online form, two qualitative tests were given to the participants to assess their perception of the changes made, one prior to the application of the treated glass in the lighting on day 125, and another at the end of the study on day 150.

Fig. 6 Vitrocuantic® glass pieces with vibrational identity thermomechanical treatment.

3. Results and Discussion

3.1 Emotions Wall

The emotion measurements were divided into five panels of 30 days each. In Figs. 7-9, the emotions experienced by the participants using the space are shown for each change interval (C), with their respective intensity average in the morning (AM) and in the afternoon (PM). The intensity is divided into four levels, with level 1 as the lowest intensity and level 4 the highest intensity. The physical environmental measurements (M) are located on the graphs.

Subsequently, the percentages of each emotion were presented by measurement panel every 30 days (Fig. 6), in which Happiness ranged between 50 and 80%, Disgust between 8 and 24%, Sadness between 0 and 8%, Fear between 0 and 17%, and Anger between 0 and 12%.

3.2 Physical and Environmental Measurements

The measurements are represented with the letter M and the number according to the date they were made; these measurements are identified in Graphs 1 to 3. The following average values were observed: Light: 407

lux; Table reflection: 58.7%; Ambient temperature: 23.4°C; RH: 49.4%; Noise level: 33.6 dB; Surface temperature of the elements: 24.36°C; Area: 10642; Intensity: 83.52; Energy: 6.43.

3.3 Qualitative Tests

In the following images (Fig. 11), the results of the qualitative tests are displayed, showing data on the participants' state. The first image coincides with the first phase of changes and the second with the final part of the study. In both cases, the results are shown in percentages according to the intensity of each parameter, with 1 being the lowest level and 5 the highest level.

Fig. 122 shows the results related to the perception of the environment and the changes made with the same intensity criteria as in the previous graphs.

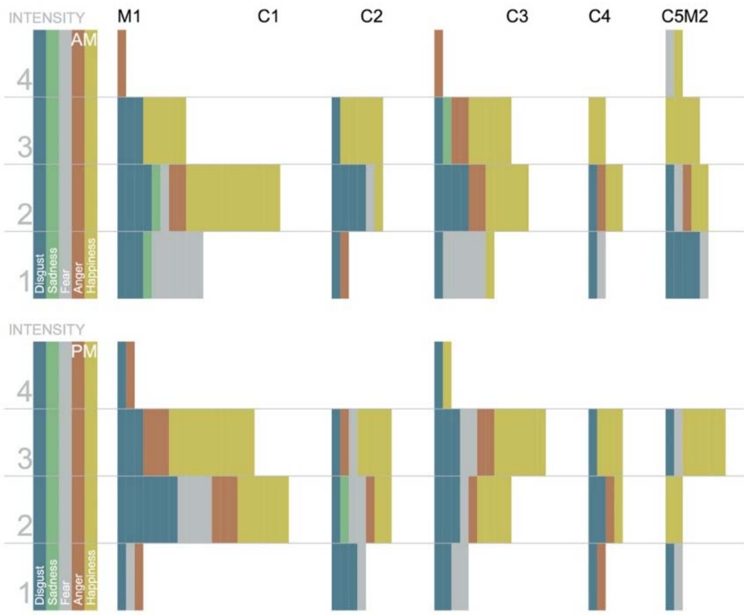

Fig. 7 Emotion results — change intervals 1 to 5.

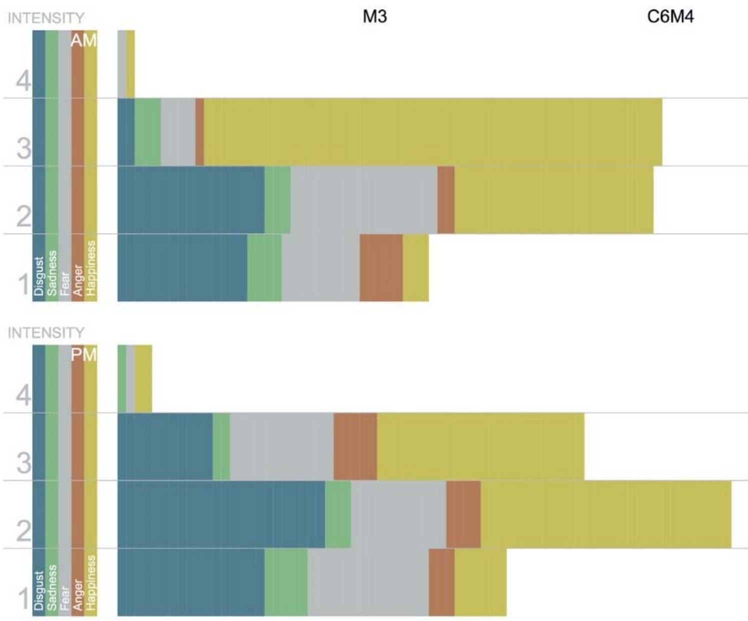

Fig. 8 Emotion results — change intervals 5 to 6.

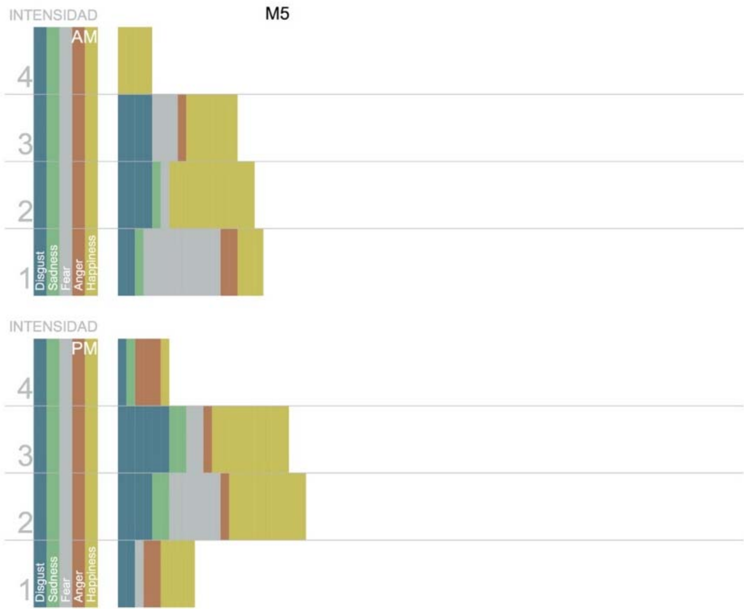

Fig. 9 Emotion results — change interval 6 up to the end of the study.

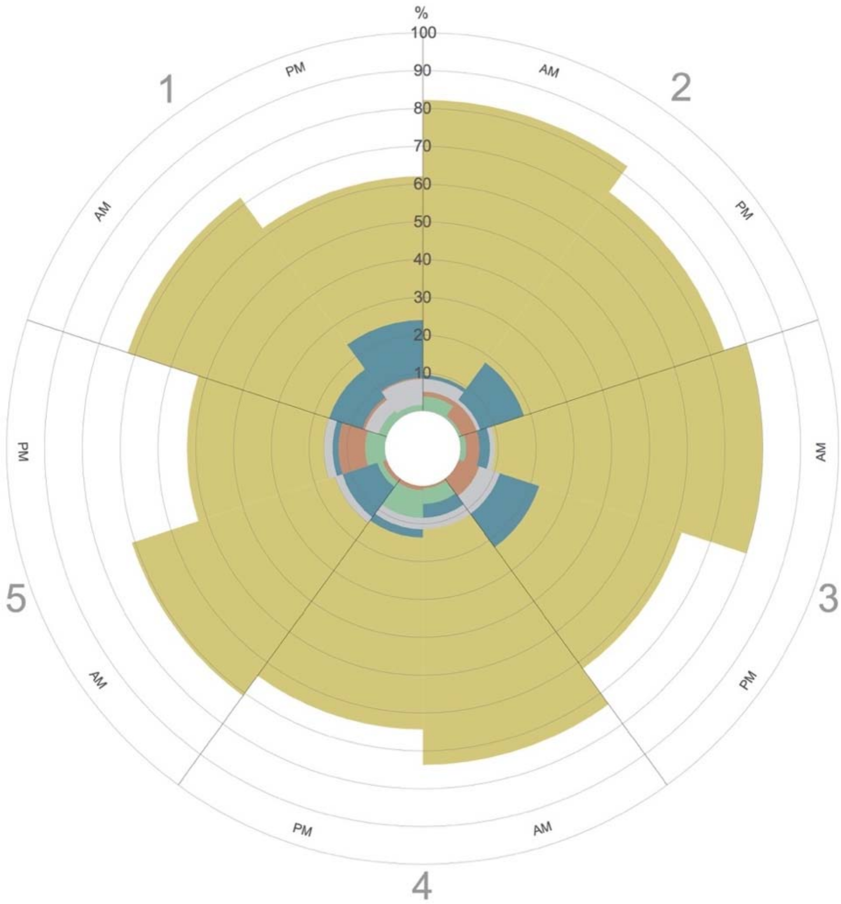

Fig. 10 Total percentages of emotions in the five AM and PM panels.

Table 1 Physical and environmental measurement results.

Measurement number	M1	M2	M3	M4	M5
Parameter					
Light (general)	460 lux	400 lux	436 lux	390 lux	350 lux
Table reflection	78.26%	48.25%	42.20%	79.48%	45.70%
Ambient temperature	22.1°C	21.9°C	22°C	27°C	24.4°C
RH	52.80%	50.90%	43.40%	52.20%	47.70%
Noise level	30 dB	40 dB	30 dB	30 dB	38 dB
Temperature of the elements					
Table	22°C	26°C	24°C	27.3°C	25°C
Pavement	22°C	22.8°C	24°C	25°C	25°C
Wall	23°C	23.5°C	23.8°C	26.6°C	25°C
Sky	24°C	23.5°C	24°C	26.7°C	24°C
Energy-GDV (2 measurements — 10 mins each)					
Area	1902.65	39482	4801.41	4402.18	3698
Intensity	42.54	192	67.09	60.57	57.94
Energy	0.35	30	1.28	1.13	0.857
Area	2035.8	36541	5098.92	4648.05	3810
Intensity	42.37	188	67.57	61.42	55.78
Energy	0.37	27	1.37	1.14	0.85

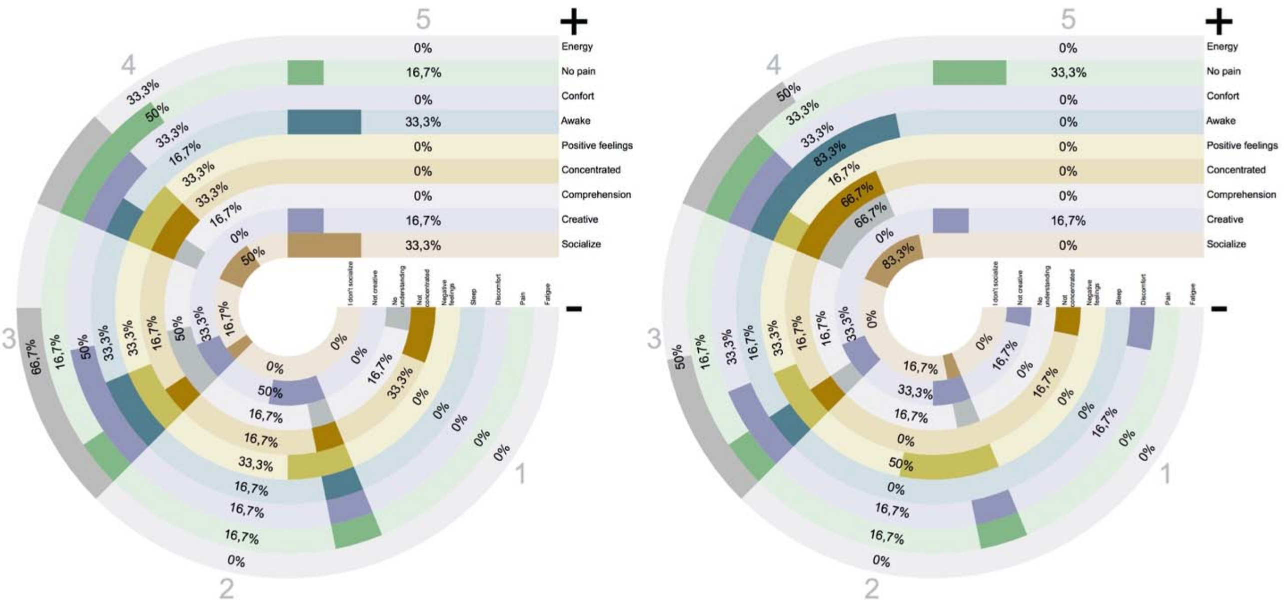

Fig. 11 Results of the states or levels related to: energy, well-being, comfort, awareness, feelings, concentration, comprehension, creativity, and sociability.

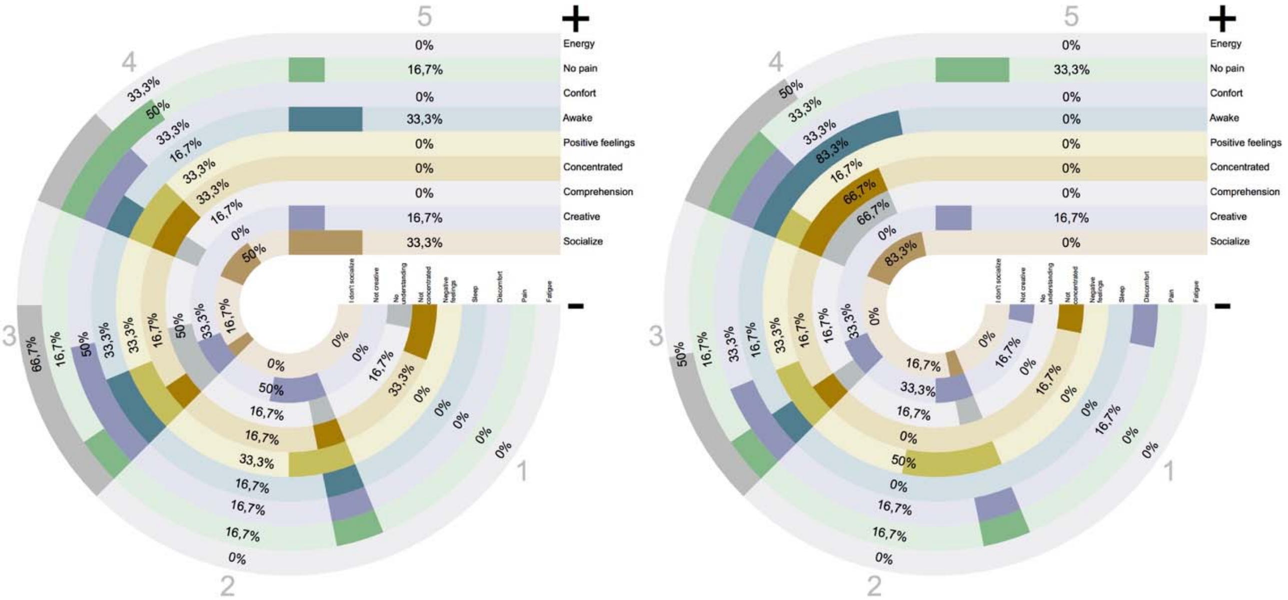

Fig. 12 Perception of the environment: lighting, brightness, color, temperature, humidity, ventilation, noise, and atmosphere.

With respect to the question related to the perception of the changes made to the space, 100% of the participants stated that they were to their liking. They also agreed that the environment influences them: 83.3% say they felt positively affected and 16.7%, negatively.

3.4 Discussion and Interpretation

One can observe in the above graphs that, in Fig. 10, the presence of happiness in all panels stands out as having a percentage value that is always slightly higher in the morning than in the afternoon. This data can be corroborated in Figs. 7-9, where it appears more often and with an average intensity above 2 out of 4. The other emotions are distributed across smaller percentages and present small differences between AM and PM, with the percentage of disgust showing a higher value in the afternoon. In addition, the emotions have a different distribution across the three graphs since some emotions are non-existent during certain change intervals, for example, sadness in Fig. 7, change intervals 1-3.

The analysis of the graphs corresponding to the panels, Figs. 7-9, shows how, at the beginning of the case study before the first change, there were up to four different emotions per AM/PM period. In addition, happiness dominated, with an average intensity of 2-3, followed by disgust, which appeared on certain occasions. When making the first change, on the 16th day, everyone was happy and maintained this state until the second change, along with disgust on occasion and anger only three times. From the second change to the following intervention, the absence of sadness stands out, with disgust appearing more frequently at an intensity of 1-2 and happiness continuing to stand out. From day 33 to 37 — change interval from 3 to 4 — when the lights were applied, happiness continued to stand out although the presence of anger across a few days should be mentioned. From the application of the lights up to day 44 — change 5 — happiness presented a greater intensity and disgust decreased. Fear appeared rarely, but with strong intensity. From this penultimate modification to the application of the glass pieces — change 6 — over 60 days elapsed, a significant time frame to assess emotions with the modifications already in place, thus eliminating the factor of surprise or novelty. The maximum presence of four emotions per AM/PM period and the greater intensity stands out. Happiness continued to be strong, coexisting with a greater presence of fear and sadness, while anger was rarely observed. From said change until the end of the study, happiness decreased in intensity and fear and disgust increased instead, coinciding with the end of the academic year.

Finally, the measurements of the physical environmental parameters were related to the users' perception of their state and environment. Regarding light, the values decreased from 460 to 350 lux, and the perception went from being quantified as a lot 33.3%, sufficient 33.3%, and normal 33.3% to a lot 16.7%, sufficient 50%, and normal 33.3%. Reflection decreased from 78.2% to values in other measurements at 45%, and, if compared to the perception of brightness, the highest percentage, which was perceived as a lot, became perceived as sufficient. As to the temperature, it increased as summer arrived, but the users' perception of temperature remained normal, likely due to the air conditioning system and the possibility of regulating it. Humidity subtly dropped in percentage and, in terms of perception, it improved and became quantified as normal. Noise remained constant in decibels, but the perception of noise improved as it showed a better percentage as normal. Finally, the energy measurements increased with respect to M1 and perceptions also improved in terms of energy, comfort, concentration, and comprehension.

4. Conclusions

This research aimed to correlate physical and environmental parameters, emotions, and modifications in a work space through different types of tools and tests. The main objective was to understand and contribute to obtaining data to subsequently impact creative processes by applying a more holistic view of well-being. Emotions are part of people's daily lives. Therefore, understanding them will help encourage users both personally and in terms of performing their tasks. The results of the case study show that there are direct correlations between physical parameters and user perceptions, such as light, humidity, and so forth, and others that should continue to be explored in order to provide more convincing conclusions, such as energy, comfort, sociability, and more.

For future research, it would be interesting to continue with new case studies, as well as taking the research to other areas. A first test of the EAD (Emotional Analogous Data) tool has already been initiated in paper format in the ELISAVA Creative Process Master's Program to measure emotions based on learning spaces and the type of methodologies, as well as in final degree projects to understand emotions based on the creative process of a project and the conditions of the space in which work is being done.

Acknowledgements

The authors would like to thank ELISAVA, Barcelona School of Design and Engineering, the University of Santiago, Chile (USACH), the International University of Catalonia (UIC), the Polytechnic University of Catalonia (UPC), and Xavier Vilajosana from Vitrocuantic® — this paper would not have been possible without their support.

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