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Research Article

Gender-related Differences in Perceived Productivity and Indoor Environmental Quality Acceptance-Results of a Questionnaire Survey in University Workplaces

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Abstract: Improving occupant's satisfaction represents an important target oriented both towards the increment of productivity and towards the reduction of operational costs related to health and safety of employees. These considerations are the bases of an interdisciplinary cross-country survey on the human-building interaction in office buildings. The proposed study presents findings from the survey conducted at the University of Calabria (Italy). In particular, both demographic characteristics of the sample and data regarding comfort, satisfaction, and productivity are processed and investigated. Descriptive statistical analysis is developed with the aim of highlighting the influence of indoor comfort conditions on the perceived productivity of employees. Particular attention is dedicated to the study of gender-related differences in internal environment perception. Indoor temperature, quality of indoor air, and acoustics are the most selected causes of dissatisfaction and low perceived productivity both for women and men. The responses regarding satisfaction level and perceived productivity are also combined by defining a quantitative indicator named Office Productivity and Satisfaction index (OPSi) that is the ratio between the perceived productivity and the satisfaction level of the considered comfort condition. Causes of discomfort are also analyzed and demonstrated gender-related differences in workplaces quality evaluation.

Keywords: *Office buildings, Survey, Indoor comfort, Satisfaction, Productivity, Gender*

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1 Introduction

Energy consumption in office buildings is the result of a twofold contribution: consumption caused by work equipment and that one that assures a healthy and comfortable internal environment for the occupants. It is known that occupants play a key role in the energy use of office buildings and they are often perceived as one of the main causes of underperforming buildings. It is consequently necessary to understand the factors influencing energy intensive occupant behaviors and to incorporate them in building design. In fact, occupants are not irrational but they try to restore their comfort conditions in the easiest way possible[1]. Even less it is available in the literature about the effect of negotiated behaviors on the occupants' satisfaction in terms of preferred indoor thermal conditions and the level of perceived control[2].

During the last decade, great effort has been dedicated to studying comfort in office buildings by considering the occupants' perspective. In fact, people spend about 90% of their time in indoor environment[3,4], and it is recognized that diverse symptoms of discomfort from the indoor environment produce a significant reduction in work performance[5]. For instance, studies conducted in the UK showed that a comfortable office environment could help to increase productivity up to 20%[6].

1.1 The multi-factor aspect of indoor comfort

Comfort-related problems can be investigated from diverse perspectives. The most popular methodological approach includes the collection of both qualitative and quantitative findings and the individuation of both personal and environmental variables. Furthermore, given the multi-parametric nature of comfort, it is necessary to examine the acceptable levels of all the conditions: thermal, visual, and acoustic comfort, along with indoor air quality, as stated by the International Standards[7]. Regarding thermal comfort, the recent establishment of adaptation models constituted an important innovation in thermal comfort issues, as it introduced a new methodological approach. Thus, thermal comfort is no longer defined through the PMV index, but includes the adaptation ability of occupants and their interactions with the indoor environment. The adaptive responses of occupants to their thermal environment, such as windows opening, heating/cooling switching, and personal clothing insulation adjusting, play a key role in regulating the human thermal environment. Furthermore, in addition to physical factors, the adaptive responses are determined by non-physical factors, such as thermal history, thermal expectations, and habits[8].

Visual comfort is another important component of comfort and its characterization can be achieved through the determination of many related parameters such as luminance distribution, illuminance, glare, color aspects, flicker, and stroboscopic effects, lighting of work stations with display screen equipment[9].

Acoustics condition has also to be optimized. In fact, the reduction of any possible sound that can be considered as noise by the occupants is essential because it can have a negative impact on their concentration and productivity level. Based on the study presented by Pellerin et al.[10], the discomfort caused by a 1°C temperature change is similar to the one caused by a 2.6 dB change. Generally, indoor air quality is correlated with indoor environmental conditions and not directly with the occupants' comfort. The main reason for this mislead is the link of air quality with the occupants' discomfort due to smell in the area[11]. In that sense, the personal perception of the indoor air freshness can be expressed by the acceptable levels of CO_2 concentration as this is an index for classifying the sufficiency and quality of ventilation.

Furthermore, Bluyssen et al.[12]showed that perceived comfort is strongly influenced by several personal, social, and building factors and that their relationships are complex. Results showed that perceived comfort is much more than the average of perceived indoor air quality, noise, lighting, and thermal comfort responses. Perceived comfort is a phenomenon that still requires more investigation.

Researchers elsewhere noted that occupants' age, body constitution, and gender influence their comfort perceptions. A yearlong study on 596 office occupants in a thermal comfort field experiment was conducted in Indonesia[13]. The results demonstrated that comfort perceptions vary with gender, body mass index and ethnicity. Gender differences in thermal comfort, preferences, and use of thermostats in every day of over 3000 occupants were discussed in a Finnish investigation[14]. Aspects of indoor environmental quality and gender differences in the occupants' perception were also investigated in a research conducted by Kim et al.[15]. Furthermore, the experimental results of a study conducted in India[16] demonstrated that females, young subjects, and people with low body mass index had higher comfort temperatures than males,older people, and obese occupants, respectively. The researchers found a difference of 0.3-1.0 K in various groups. Furthermore, in naturally ventilated environments, females were comfortable at 28.5°C and men at 27.8°C. Generally, women accepted indoor conditions better.

The aim of the field study led by Maykot et al.[17] was to determine the comfort temperature for men and women in two office buildings located in Florianopolis (Brazil), one operating under mixed-mode strategy (naturally ventilated and/or air-conditioned) and one fully air-conditioned. Overall, the comfort temperature was 24.0°C for females, and 23.2°C for males. In the mixed-mode building, comfort temperature was statistically higher for females than that for males (23.7°C and 23.0°C, respectively). In the fully air-conditioned building, significant differences in comfort temperature between females and males (24.2°C and 23.4°C, respectively) were found. Furthermore, when the mixed-mode building operated under natural ventilation, the comfort temperatures tended to be lower for both men and women when compared to the comfort temperature found in the same building during air-conditioning operation.

Discomfort can also affect the health of workers. In this respect, it is important that individuals of both genders are satisfied with the ambient conditions. Closed buildings operating at inappropriate temperatures, in addition to other factors, could lead to the 'sick building syndrome', which is responsible for symptoms such as headaches, irritation, dry or itchy eyes, nasal problems, sore throats, breathing problems, fatigue, and concentration problems[17].

1.2 Satisfaction and perceived productivity in office buildings

The Center for People and Buildings in Delft, The Netherlands, conducted a consistent number of case studies into employee satisfaction with the working environment and perceived productivity[18]. Researchers found (over 10000 respondents from 71 case studies) that the ability to concentrate has a substantial influence on the perceived productivity. Respondents that were more satisfied with the ability to concentrate were also more likely to experience the workplace as supportive for their productivity.

Hellwig et al.[19] proposed a new definition of satisfaction, where it is considered as a cause of both comfort or pleasure, not exclusively of comfort. While comfort results from homeostasis, pleasure is caused by a successful control behavior. Furthermore, the equilibrium of environmental factors in a person differs with time, internal state, activity, and expectations.

Within the European research project HOPE[20], questionnaires were delivered to the occupants of 96 apartment buildings and 64 office buildings regarding their satisfaction in terms of comfort (thermal, visual, acoustical, and IAQ) and their perceived health (Sick Building Syndrome and allergies). Strong correlations were found between perceived indoor air quality, thermal, acoustic, and lighting comfort. Significant correlations between the perceived comfort and building-related symptoms were also encountered, and comfortable and healthier buildings being well distinct from uncomfortable ones. Occupants were also asked how much their productivity was increased or decreased, in summer or in winter. Too high temperatures in summer decrease the perceived productivity. In winter, the productivity tends to decrease if the temperature is perceived as not satisfactory.

Furthermore, another research examined the relationship between individual thermal satisfaction and worker performance[21]. Field measurements and a questionnaire survey were conducted within an organization participating in the COOL BIZ energy conservation campaign. The results of the subjective experiment indicated that performance during simulated office work increased with greater individual thermal satisfaction. The authors concluded that perceived thermal satisfaction of occupants is reflected in the objective measurement of office work performance, this result has practical implications for the evaluation of thermal satisfaction in real offices as a means to increment workplace productivity.

Chandra Pratama Putra[22] considered the effect of indoor thermal condition to building's occupant satisfaction in offices located in Malaysia. A questionnaire survey was performed to assess the strength of association between thermal comfort and occupants' satisfaction. A total of 20 questionnaires were distributed to the office workers. The results demonstrated that the condition of the temperature inside office rooms was not the only factor that contributes to the dissatisfaction of building's occupants. In fact, the findings revealed that 40% of occupants were dissatisfied on thermal condition due to hot condition. Additionally, the air velocity perceived by the occupants was low and resulted in the 40% dissatisfaction among the workers. Finally, the study concluded that the relationship between indoor environmental quality to produce occupant satisfaction is a complex system that needs to be assessed comprehensively.

The study presented by D'Oca et al.[23] results from an interdisciplinary survey assessing contextual and behavioral factors driving occupants' interaction with building and systems in offices located across three Italian cities. The authors attempted to identify climatic, cultural, and socio-demographic influencing factors, as well as to establish the validity of the survey instrument and robustness of outcomes for future studies. Also, the paper aimed at illustrating why and how social science insights can bring innovative knowledge into the adoption of building technologies in shared contexts, thus enhancing perceived environmental satisfaction and effectiveness of personal indoor climate control in office settings and impacting office workers' productivity and reduced operational energy costs.

1.3 Aim of the study

In this study, findings from a questionnaire survey conducted at the University of Calabria (Italy) are presented.

In particular, data regarding comfort, satisfaction, and perceived productivity of workers are processed and analyzed. The responses regarding satisfaction level and perceived productivity are also combined by defining a quantitative indicator named Office Productivity and Satisfaction index (OPSi). Discomfort causes were also considered. The study aimed to investigate specifically the differences between male and female workers about their perception of indoor conditions.

2 Methodology

The study is based upon a cross-country survey on the human-building interaction in university offices developed by a multidisciplinary team to collect responses from administrative staff, professors, researchers, Ph.D. students, and visiting researchers among universities and research centers located in America, Asia, Australia, and Europe (see Figure 1).

The scientists involved in the investigation developed a research framework by synthesizing building physics with social science for studying human-building interaction in office settings[24]. In particular, three theories were considered: the Social Cognitive Theory (SCT)[25], the theory of planned behavior (TPB)[26], and the DNAS framework for energy-related behaviors[27, 28]. By using a double translation process[29], the survey was translated from English to four languages (Italian, Polish, Hungarian, and Chinese). In Italy, the questionnaire was delivered from April 5th to May 8th, 2017.

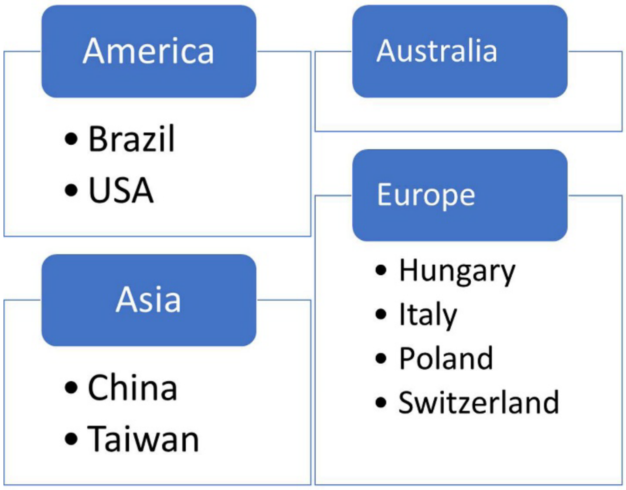

Figure 1. Countries involved in the study.

2.1 Questionnaire content and targets

The survey consists of 37 questions summarized in Figure 2 and aims to understand:

-the environmental, cognitive, and behavioral motivational drivers influencing the human-building interaction in diverse office settings and cultural contexts;

-the interaction of workers with control systems and how group decision is made to negotiate and share control of equipment;

-the adaptive actions to improve comfort conditions;

-the perceived satisfaction and productivity.

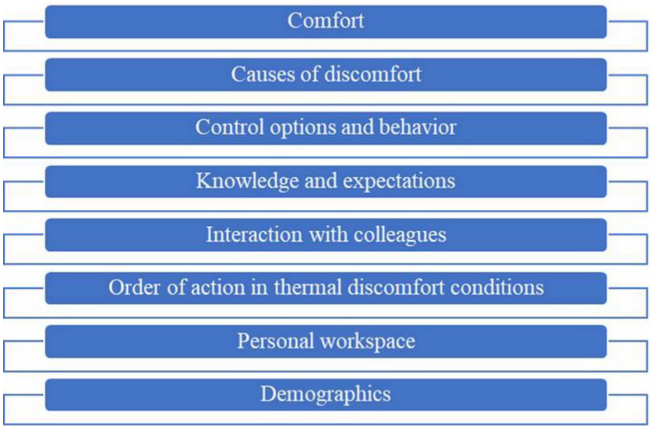

Figure 2. Survey contents.

2.2 Location, buildings, and participants

The questionnaire survey was delivered at the University of Calabria (Unical), Italy. Unical is a public institution founded in 1972 and created around the concept of a Campus. Covering an area of 200 hectares, it is located in the hilly area of Rende (39°21'53.8"N 16°13'32.5"E). As defined by the Köppen-Geiger climate classification system, this geographic area is characterized by a typical hot-summer Mediterranean climate (Csa)[30]. Specifically, the climate in Rende is warm and temperate, and the rain falls mostly in the winter, with relatively little precipitation in the summer. In particular, during the data collection period, the daily values of the external air temperature varied from 14.2°C to 26.6°C, with a mean value of 19.5°C. The hourly mean values of temperature are shown in Figure 3.

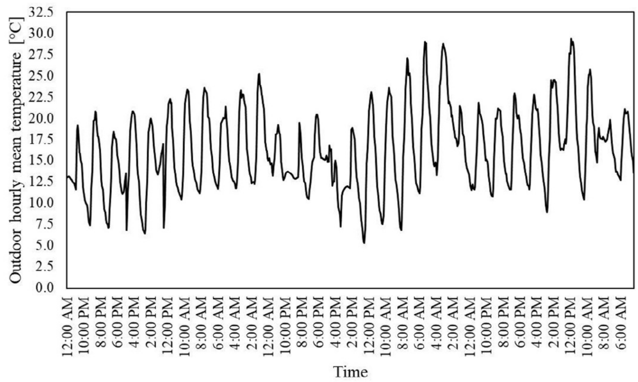

Figure 3. Outdoor hourly mean temperature measured at the University of Calabria during the survey period (from April 5th to May 8th, 2017).

The university campus presents two types of buildings: the majority are concrete buildings; the other typology is made of wide glazed facades (see Figure 4).

Figure 4. Building types at the University of Calabria. a) Concrete buildings and b) buildings with glazed facades.

The questionnaire survey was emailed to 1598 participants. The sample, mainly composed of men (59%), has an average age of 50.6 years. In fact, the most populated categories are those ones that group workers from 40 to 50 years (35.3%) and from 51 to 61 years (35.7%). 94% of employees have Italian nationality, the remaining 6% includes 30 different nationalities. Almost half of the sample is represented by administrative staff (48%).

2.3 Investigated questions

Besides the demographic characteristics of the sample, the analyzed questions in this work were those ones regarding perceived comfort, satisfaction, and perceived productivity of Unical employees. Four indoor comfort conditions were considered: thermal, visual, acoustic, and air quality.

The selected questions from the survey that were analyzed are:

●*Please tell us how you CURRENTLY feel in your workspace*

●*To what extent are you SATISFIED or NOT SATISFIED with the following conditions in your workspace?*

●*How would the following conditions influence your current PRODUCTIVITY at work?*

Respondents used a 7-point Likert scale for comfort and a 5-point Likert scale for satisfaction and productivity.

Causes of discomfort for each internal condition were also investigated by using multiple choice questions:

●*How would you best describe the sources of your…… discomfort at work, if there are any?*

3 Results

3.1 Demographic information

The response rate reached 16% and the mean completion time was 28.1 minutes. The demographic characteristics of the respondents (N=253 people) are summarized in Table 1. In particular, the final sample was composed by 53% of men, 43% of women; 4% of respondents declined to provide their gender. One can see that the more numerous category that filled out the survey was the administrative staff (39%), followed by researchers (25%). The age ranges more densely represented in the sample were from 40 to 50 years (34%) and from 51 to 61 years (32%). Regarding the highest level of education, almost half of the respondents had a doctoral degree (46%).

Table 1. Demographic characteristics of the sample: gender, work position, age range, and the highest level of education

Variable	Respondents [%]
Gender	
Male	53
Female	43
I prefer not to answer	4
Work position	
Faculty (Professor or Lecturer)	21
Administrative staff	39
Ph.D. Student	12
Researcher	25
Visiting Researcher	0
Other	3
Age	
18-28 years	9
29-39 years	16
40-50 years	34
51-61 years	32
62 years or older	8
Other or prefer not to answer	1
Highest level of education	
Did not finish or have not finished high school	0
High school diploma	12
Bachelor degree or equivalent	4
Master degree or equivalent	34
Doctoral degree	46
Other or prefer not to answer	4

3.2 Perceived thermal comfort

The first analyzed variable is the perceived thermal comfort in the workspace. Based on a Likert Scale, respondents chose a vote from 1 to 7, where 1 indicates hot discomfort (1=Hot) and 7 indicates cold discomfort (7=Cold).

As shown in Figure 5, around half of the sample (54%) appears to be neutral, only a few people reported to have a strong discomfort: 2% and 1% for hot and cold discomfort, respectively. Strong discomfort was mostly found for the female gender, only women declared Cold discomfort and 60% of respondents that said Hot discomfort were once again women. Moderate warm discomfort was distributed mainly among men; while women more frequently declared moderate Cold discomfort.

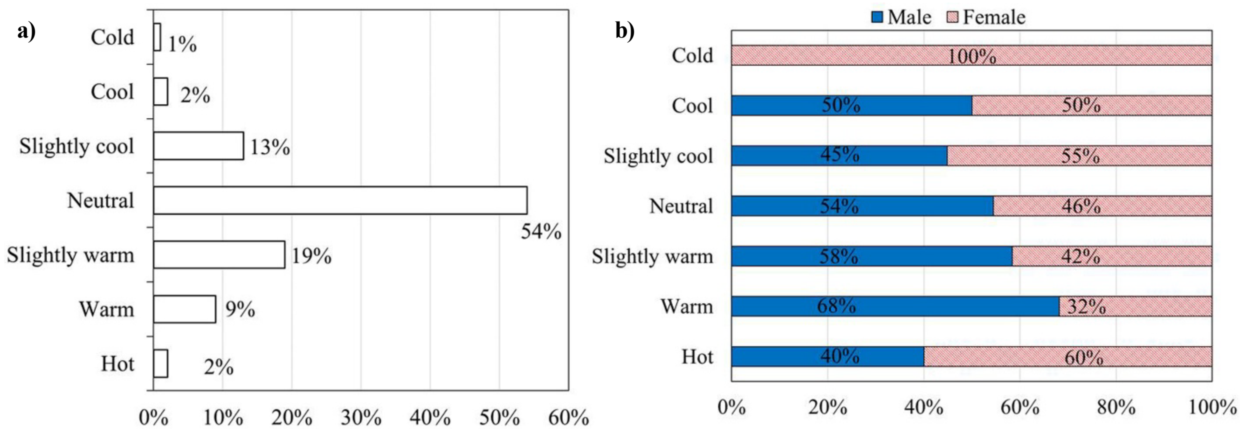

Figure 5. a) Perceived thermal comfort and b) Perceived thermal comfort as a function of gender

3.3 Satisfaction

Likert Scale was also used to measure satisfaction level. The values from 1 (Very unsatisfied) to 5 (Very satisfied) were chosen by workers to indicate their satisfaction with five conditions: indoor temperature, quality of indoor air, quality of acoustics, quality of natural lighting, and quality of artificial lighting. How can be noted from data shown in Figure 6, there is a prevalence of Somewhat unsatisfied answers for indoor temperature, quality of air, and acoustics (30%, 32%, and 29%, respectively). About natural and artificial lighting, the biggest percentage was registered in Somewhat satisfied class (35% and 36%, respectively). The percentage of Very satisfied is lower than 10%, except in the case of natural lighting that shows 20% of answers. The percentage of respondents that declared Very unsatisfied is lower than 15% for all comfort conditions.

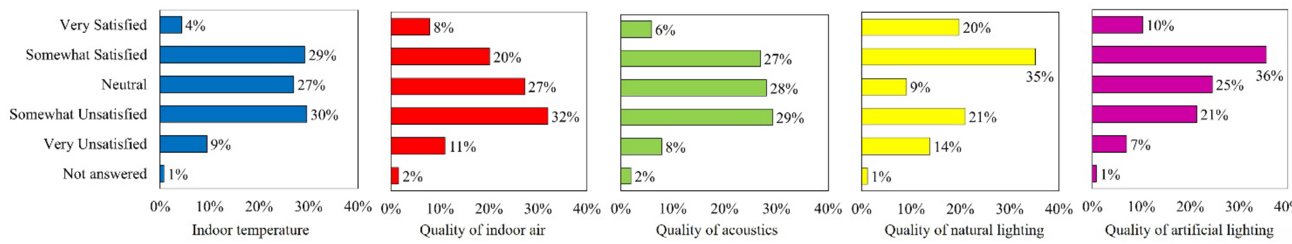

Figure 6. Satisfaction about indoor temperature, quality of indoor air, quality of acoustics, quality of natural lighting, and quality of artificial lighting

Table 2 shows the mean satisfaction value for the entire sample and as a function of gender. All the considered conditions present a mean value of more than 2.5 out of 5. It can be inferred that the respondents are more satisfied about the quality of natural and artificial lighting that present the highest mean values of satisfaction: 3.23 and 3.17, respectively. Such a satisfaction is more declared by women (3.37 and 3.28).

Table 2. Mean value of satisfaction. For the total sample and for gender

Condition	Total	Men	Women
Indoor temperature	2.87	2.87	2.90
Quality of indoor air	2.77	2.85	2.75
Quality of acoustics	2.88	2.89	2.86
Quality of natural lighting	3.23	3.17	3.37
Quality of artificial lighting	3.17	3.10	3.28

3.4 Perceived productivity

Respondents selected a value from 1 (Very negatively) to 5 (Very positively) to indicate how their perceived productivity was affected by the internal environmental conditions. One-third of the sample declared to be neutral; Somewhat negatively was the second common choice, except for lighting conditions for which workers selected the option Somewhat positively in the 28% of cases (see Figure 7). One can see that the conditions which have a more negative impact on the perceived productivity are the indoor temperature and the quality of indoor air. On the other hand, the quality of natural and artificial lighting seems to have a positive impact on perceived productivity.

The average values recorded for each condition that influences the perceived productivity are shown in Table 3.

The values calculated for the entire sample are in accordance with the comments made for Figure 7.

Table 3. Mean value of perceived productivity. For the total sample and for gender

Condition	Total	Men	Women
Indoor temperature	2.91	2.96	2.86
Quality of indoor air	2.90	2.99	2.84
Quality of indoor acoustics	2.85	2.87	2.83
Quality of natural lighting	3.25	3.27	3.25
Quality of indoor artificial lighting	3.01	3.05	2.97

Regarding gender, it can be inferred that men showed higher perceived productivity than women do in all indoor conditions.

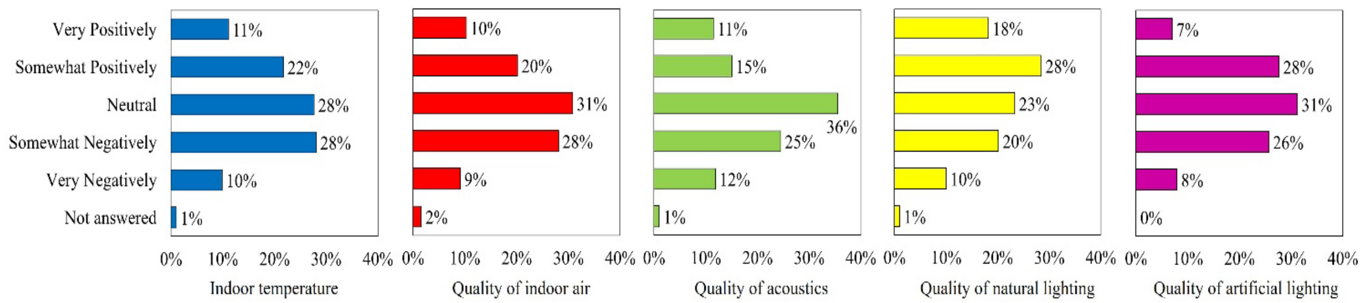

Figure 7. Perceived productivity due to indoor temperature, quality of indoor air, quality of acoustics, quality of natural lighting, and quality of artificial lighting

3.5 OPSi: Office Productivity and Satisfaction index

For each indoor condition, the responses regarding satisfaction level and perceived productivity were combined by defining a quantitative indicator, the Office Productivity and Satisfaction index (OPSi). The $OPSi_{(x)}$ is the ratio between the perceived productivity and the satisfaction level of each respondent for the x condition:

$$\boldsymbol{OPSi_{(x)}} = \frac{\boldsymbol{PP_{(x)}}}{\boldsymbol{S_{(x)}}} \quad (1)$$

Where:

●PP is the perceived productivity;

●S is the satisfaction level;

●x is the considered condition (indoor temperature, quality of indoor air, quality of acoustics, quality of natural lighting, quality of artificial lighting).

Three clusters of OPSi were identified:

●OPSi < 1 groups people that despite a high score of satisfaction, chose a low value of perceived productivity;

●OPSi = 1 includes people that assigned the same value for satisfaction and productivity;

●OPSi > 1 embraces people that assigned a high value of perceived productivity even though the low value previously assigned to satisfaction.

The percentage of respondents contained in each individuated cluster is shown in Table 4. Around or more than 50% of the responses are grouped into the class OPSi=1, the rest is split equally into the other two clusters, except in lighting conditions that present a higher and more significant percentage of OPSi< 1 (33%) than OPSi>1 (18%). This Table also contains the clusters obtained considering gender. By comparing the results, it can be noted that there are not substantial differences between the total clustering and the clustering obtained by gender diversification.

Table 4. OPSi obtained for each considered indoor condition

Condition	Respondents [%]			Male respondents [%]			Female respondents [%]		
	OPSi <1	OPSi =1	OPSi >1	OPSi <1	OPSi =1	OPSi >1	OPSi <1	OPSi =1	OPSi >1
Indoor temperature	24	51	25	25	51	24	22	51	27
Quality of indoor air	22	50	28	20	52	28	23	49	28
Quality of acoustics	26	54	20	25	52	23	25	57	18
Quality of natural lighting	27	51	22	29	43	28	26	59	15
Quality of artificial lighting	33	49	18	30	48	22	37	49	14

Successively, the authors focused their attention on the group OPSi=1 with the aim of understanding if the equality was derived from low (1, 2), neutral (3) or high (4, 5) values of satisfaction and perceived productivity. In particular:

● $OPSi^-$ includes all the respondents that declared to be unsatisfied and negatively influenced by the considered condition;

● $OPSi^=$ groups only respondents that said to be neutral;

● $OPSi^+$ contains the employees that felt satisfied and positively influenced by indoor conditions.

The results, for all the entire sample and for gender classification, are shown in Figure 8 a-c. In general, the main part of the workers presents negative OPSi due to indoor temperature (43%), quality of indoor air (50%), and quality of acoustics (41%). On the other hand, 53% and 39% of respondents have positive OPSi regarding the quality of natural and artificial lighting, respectively. Male workers present mostly OPSi- for temperature (37%), air quality (46%), and artificial lighting (44%). Instead, female employees are also unsatisfied for acoustics condition (43%), and more satisfied about artificial lighting (30%).

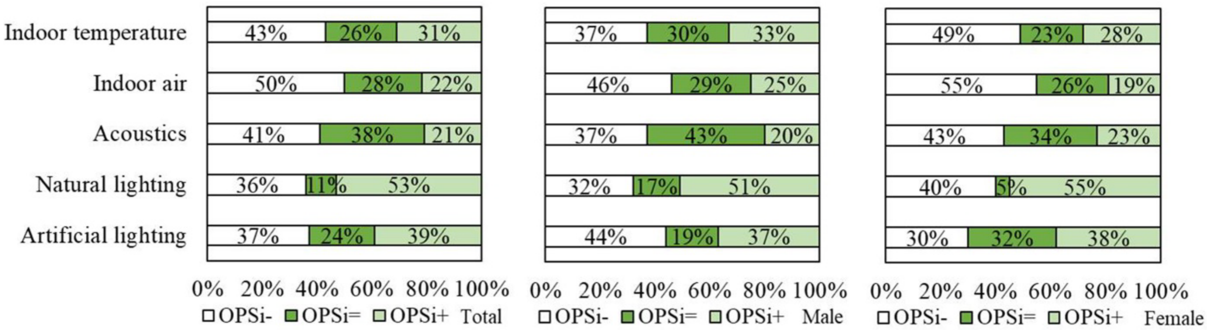

Figure 8. Negative, neutral, and positive OPSi ($OPSi^-$, $OPSi^=$, and OPS^{i+}) for each considered indoor condition for the total sample and for gender.

3.6 Causes of discomfort

Workers declared to be annoyed by diverse factors from systems operating or buildings envelope characteristics. Figure 9 shows the percentage of male and female workers that identified causes of discomfort. A significant percentage of respondents, variable from 55% to 71% depending on the condition, individuated discomfort motive. Thermal, visual, and acoustic discomfort reasons were principally issued by men.

More to the point, Figure 10 illustrates the causes of discomfort for each internal condition by considering gender diversification.

Regarding thermal discomfort, workers mainly declared to suffer air drafts (from windows and/ or air conditioning systems) with a comparable percentage in males and females (25.3% and 31.2%, respectively). Discomfort was also

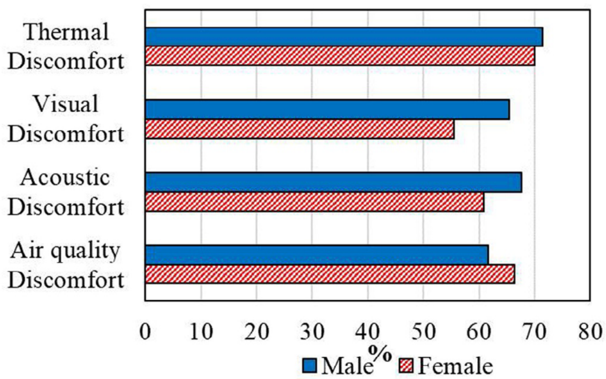

Figure 9. Percentage of male and female workers that declared discomfort

caused by localized temperature variations in the indoor environment (workspace hotter/cooler than other areas) and on the internal surfaces (walls/floors too hot/cold) with a percentage around the 20% of respondents. In particular, women were more affected by cold workspaces (23.4%) and men by hot internal surfaces (23.2%). The most recorded cause of thermal discomfort appeared the absence of thermostat accessibility and, as a consequence, the lack of control over the temperature level. Especially men selected this cause of discomfort (42.1%). Furthermore, male workers declared thermal discomfort caused by ineffective heating/ac systems (12.6%).

Visual discomfort was determined principally by inadequate natural lighting considered too low from the 41.4% of men and from the 52.5% of women. On the other hand, glare was the cause of discomfort for 40.2% of men and for 31.1% of women. The common answer was also the poor view of outside chosen by 30% of respondents.

Acoustic discomfort caused by internal noises was selected by a consistent percentage of women: 59.7% were disturbed by chatting and poor insulation from other spaces, and 37.3% were annoyed by equipment and mechanical systems. Lower but significant percentages were recorded for men (47.8% and 31.1%, respectively). Noise from outside was strongly felt by male workers (56.7%) and to a lesser extent from female employees (34.3%).

Bad/strong odors and stuffy/stale air are causes of discomfort in the 40% of male and in the 30.1% and 49.3% of women, respectively.

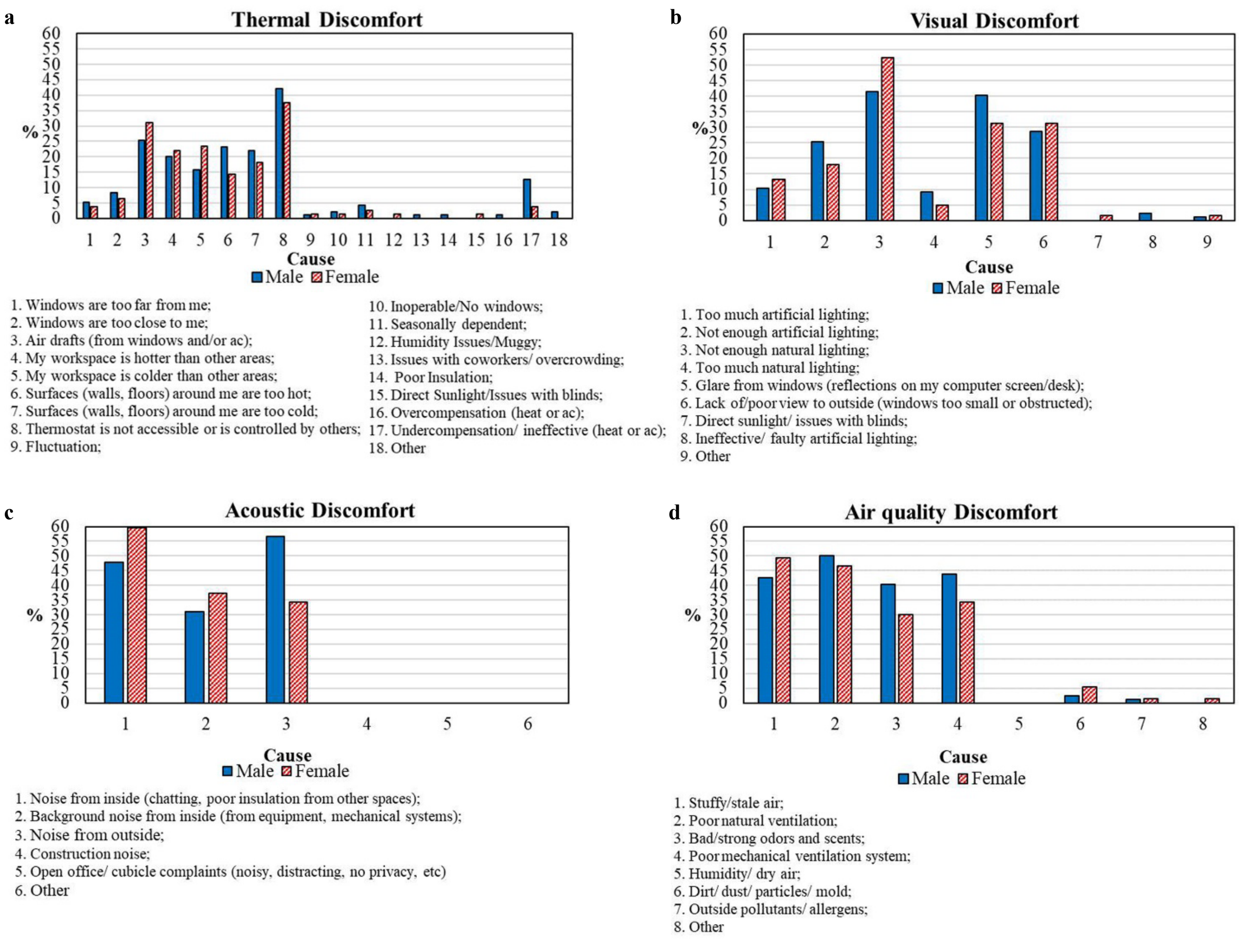

Figure 10. Discomfort causes as a function of gender. a) Thermal discomfort, b) Visual discomfort, c) Acoustic discomfort, d) Air quality discomfort.

4 Conclusions

The paper presents the results of a study conducted at the University of Calabria (Italy) by using a questionnaire designed to understand the motivational drivers of employees in interacting with shared building environmental controls, in terms of ease of usage and knowledge of building technologies, and the factors that most influence perceived comfort, satisfaction, and perceived productivity.

The first part of this study was dedicated to the demographic characterization of the sample by taking into account also gender composition. Gender preferences were analyzed in the study of perceived thermal comfort and the results demonstrated that moderate warm discomfort is mainly distributed among men; while women frequently declared moderate cold discomfort. Five conditions were considered for collecting information about satisfaction: indoor temperature, quality of indoor air, quality of acoustics, quality of natural lighting, and quality of artificial lighting. The sample showed positive satisfaction for natural and artificial lighting, especially women. The effect of indoor conditions was also investigated in reference to perceived productivity. The results demonstrated that the conditions which have a more negative impact on the perceived productivity are the indoor temperature and the quality of indoor air. Quality of natural and artificial lighting seems to have a positive impact on workers. Moreover, men showed higher perceived productivity than women in all categories of indoor conditions. For each indoor condition, satisfaction and perceived productivity have been related by introducing a quantitative indicator, the Office Productivity and Satisfaction index (OPSi) defined as the ratio between the perceived productivity and the corresponding satisfaction level. Three groups were identified OPSi<1; OPSi=1, and OPSi>1. The authors considered in detail the group OPSi=1 in order to establish if the equality was derived from low, neutral or high values of satisfaction and perceived productivity. Some gender differences were found: men presented mostly low values for temperature, air quality, and artificial lighting; female employees were more satisfied with artificial lighting but unsatisfied for acoustics condition. The workplace was felt uncomfortable from a large percentage of respondents. In particular, the lack of control over the internal air temperature was the most diffused cause of thermal discomfort, especially for male workers. On the other hand, female employees declared to be more affected by inadequate natural lighting and men by glare from windows due to reflections on computer screen/desk. Women appeared more sensitive to indoor noises, and men more annoyed from outdoor disturbance. Especially men attributed low air quality to stuffy air and inadequate (natural and mechanical) ventilation.

The investigation demonstrated that comfort in workplaces is the result of combined conditions: thermal, visual, acoustic, and air quality. Also, internal quality perception and declared discomfort causes are different in women and men. In fact, technical and constructive characteristics of buildings affect negatively the satisfaction and perceived productivity with gender-related differences.

These findings can help managers of office buildings in improving workplaces design and management.

Acknowledgments

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