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# The Physical Environment in Remote Working: Development and Validation of Perceived Remote Workplace Environment Quality Indicators (PRWEQIs)

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**Abstract:** As a result of the COVID-19 pandemic, more and more organizations have implemented remote working, resulting in a partial overlap between home and work environments. This study aimed to develop a tool named Perceived Remote Workplace Environment Quality Indicators (PRWEQIs) to study the impact of the remote work environment on worker well-being. A preliminary 20-item version was developed. In Study 1, an Exploratory Factor Analysis (EFA) was conducted on a sample of remote students (N = 521); the results were confirmed in Study 2 through a Confirmatory Factor Analysis (CFA) on a sample of remote workers (N = 463). The final 15-item PRWEQIs include five indicators, Acoustic comfort, Visual comfort, Quality of the furnishings, Safety, and Space usability, and a second-order factor referring to General perceived comfort. The scale constitutes an initial instrument for assessing the perception of the physical-spatial qualities of the remote working environment.

**Keywords:** spatial-physical comfort; remote working; sustainable workplace; remote studying; scale development and validation; perceived comfort; PRWEQIs



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## 1. Introduction

The COVID-19 outbreak prompted drastic and unexpected changes in the entire society. As a result of the current crisis, an increasing number of organizations are required to introduce remote working into their activities, causing a possible disconnection of employees from their social and professional environment [1]. The expressions “remote working” or “e-working” (in Italy, commonly called “smart working”) are used to define the type of work activities that can be performed at any time, regardless of location, and characterized by the increasingly extensive and intensive use of technology to foster flexible work practices [2]. Historically, the concept of remote work was overlaid with telecommuting. This requirement refers to a flexible work arrangement that a supervisor has approved and permits an employee to work for a predetermined number of days each pay period from a location other than their official place of employment. However, in recent times, the increased flexibility afforded by remote working is gaining momentum in private and public organizations. Before the pandemic, estimates indicated a steady increase in employees who claimed their home as their primary or principal place of employment [3]. For instance, it was reported that nearly one in twenty employees throughout the EU-27 countries frequently worked from home between 2009 and 2019. Flexible applications of remote work, which combine time spent at home and at work, have become more prevalent: by 2019, 9% of employees in the EU-27 reported employing this more hybrid style of remote work, up from 5.2% in 2009 [4]. As a result of the pandemic and resulting lockdowns, more and more organizations have been forced to implement these hybrid or totally remote

forms of work. It has been estimated, for example, that around one-in-three workers reported homeworking exclusively in the UK and US in Autumn 2020 [4,5]; in the EU-27, it was estimated that around 40% of those who remained working during the pandemic shifted to homeworking at its peak in 2020 [4]. Concerning the Italian context, during the first half of 2021, remote working involved about 5.47 million workers (about 33% of the active workforce), a significant increase from 570,000 in 2019. Following the data from the Observatory for Smart Working at Politecnico of Milan, in the post-emergency phases, the pool of remote workers shrunk to about 4.38 million. These data confirm, however, how these new forms of work organization are increasingly becoming part of everyday life in what has been called the “New Normal”. In the scientific literature, however, there remains what has been called the remote work paradox about mutually incompatible consequences for employees [6]. Discordant results have related the implementation of remote working to occupational and organizational well-being [7]. The freedom to choose when and where to work is unquestionably the most valuable part of remote employment; time savings from not needing to travel have increased job satisfaction for remote workers [8]. Numerous studies demonstrate a positive relationship between remote work and organizational satisfaction [6,9–11]. Other research supports that remote workers experience greater overall well-being and less stress than office-based workers [12–14]. On the other hand, the feeling of social and functional isolation from one’s organization is unquestionably one of the major issues related to remote work [15,16]. Ineffective work information and expertise transmission might result from a lack of face-to-face, formal, and informal connections among colleagues [17,18]. Loneliness and a lack of social support were significant negative predictors of task performance, team role performance, and affective commitment [19], while also contributing to higher stress levels and emotional exhaustion [20]. According to Waizenegger and colleagues [18], fatigue, disengagement, and reduced productivity can result from feeling socially isolated at work [17]. Additionally, considering the overlap between home and work environments, the lack of boundaries between work and personal life is a problem associated with remote working [21]: decreases in well-being, engagement, and productivity are frequently reported, specifically for workers who share a home office space with others (such as a living room or bedroom) [22]. This overlap typical of remote working also extends to the issue of gender roles and domestic and family care work: the effectiveness of remote work as a technique to reduce the father–mother gap in family management is still being supported by conflicting findings [23,24]. Working women may experience more frequent instances of multitasking at work or more frequent interruptions for child management due to the blurring of the boundaries between work and home life, which is linked to gender norms [25]. Another aspect to take into account is the potential of remote work to promote sustainability by reducing the environmental impacts of commuting and office energy consumption. In particular, remote working conditions can reduce greenhouse gas emissions by reducing the number of car trips and increasing the use of public transportation [26]; it can also lead to reduced energy consumption in the workplace, as employees working remotely may use less lighting, heating, and cooling [27]. From the perspective of the New Normal, remote working will become and is already becoming a widespread organizational practice involving millions of workers. Furthermore, as previous studies have shown, it has a strong impact on the sustainable development of society as a whole, influencing issues such as individual well-being, socialization and social group membership, environmental sustainability, and gender issues. However, these sustainable development goals can only be achieved through the proper implementation of remote work, not only through work organization and work design practices [28], but especially by paying attention to the physical and environmental dimensions where this activity is carried out, and paying attention to the development of sustainable, ergonomic, and human-friendly work environments. Organizations thus aim to contribute to achieving the perfect person–environment fit, both in classic offices and in remote working conditions.

### 1.1. Spatial-Physical Comfort in the Workplace

The need for individuals to operate in a supportive environment can be read under the Person–Environment (P–E) fit theory [29–31]. According to this perspective, people look for domains that match their needs and characteristics to adapt to environments. The person–environment relationship can concern different areas, such as person–vocation fit, person–job fit, person–organization fit, etc. [32]. In cases of non-adaptation, or misfit, the individual may experience a feeling of stress, anxiety, and frustration and may be motivated to regain fit with the environment by changing something about himself or the situation [33,34]. In the working context, therefore, the setting in which the work is carried out becomes fundamental, creating offices or work environments that adapt perfectly to the objectives, tasks, and characteristics of the workers to guarantee the P–E fit. During the past decades, increasing attention has been given to the study of the relationship between Indoor Environmental Quality (IEQ; e.g., lighting, noise, air quality, temperature, etc.) of work environments, health, satisfaction, and performance [35]. This increasing attention to work environment characteristics can be traced partly to cost savings for organizations that invest in creating supportive work environments [36]. Historically, one of the first aspects to receive attention is office layout. Indeed, office layout and organization is the first artifact representing organizational culture [37] and explicitly conveys how work is organized and the worker–organization relationship. Depending on the organizational and work structure, it is possible to identify four types of offices: hive, cell, den, and club, based on the combination of private environments (cell office, from a single workstation) and open plan spaces (where there are more than five workstations) [38]. Many studies have shown that the open space office configuration is associated with less privacy and more distraction [39–43], reduced satisfaction [44–47], and lower job performance [44,47–50]. Other IEQs related to worker well-being include air quality, temperature, acoustic comfort, privacy, and lighting source [35,43,45,48,51,52]. More and more attention is paid to the presence of natural elements inside and outside the work environment due to their ability to regenerate cognitive energy and reduce stress [53,54], allowing workers to cope with various types of job demands [55,56]. In general, work environments with natural elements which follow the principles of biophilic design [57] can help reduce work-related stress [58,59], fatigue [60], and anxiety [61], promoting performance [60] and job satisfaction [62–64]. Although “remote working” is a synonym for “work from anywhere”, this form of work organization has provided, in most cases, an overlap between home and work environments [65]. This overlap has resulted in a new challenge for many workers in maintaining boundaries between home and work life [66]. As a result of pandemic lockdowns and the massive implementation of remote working, kitchens, living rooms, and bedrooms have turned into full-fledged office settings in which workers must perform, at least in part, often without these environments having the necessary features to carry out this type of activity in total safety and comfort. Suppose the physical dimensions (IEQ) that need to be paid attention to are the same as those of classic offices (e.g., temperature, lighting, noise, etc.). In that case, it is customary to consider how these environments might not meet the minimum criteria for creating a human-scale work environment. Moreover, due to the overlap between the work environment and the home environment, encroachment of the latter is inevitable, with no possibility of clearly defining the boundaries between the two domains [67]. Workers have been pushed to adjust quickly to new home office forms due to this circumstance, which could be detrimental to their well-being [15]. One of the primary issues in this field is the decreased availability of workspace [68], as well as a potential lack of privacy [67]. However, there is still uncertainty regarding the connections between the residential setting and at-home job productivity, and between IEQ and these outcomes. Preliminary results have shown that temperature [69], room size [68], and having independent rooms and workstations separate from the rest of the domestic environment [70,71] have a positive effect in terms of performance and well-being by reducing the possibility of symptoms of discomfort. Despite these initial

insights, to our knowledge, no instrument has yet been developed to assess the impact of various IEQs on the psychological well-being of the remote worker.

### 1.2. The Present Study

The general aim of this research is to develop a first indicator for the study of the perception of the environmental qualities of the remote working environment. Specifically, the aim of Study 1 is to develop the first version of the Perceived Remote Working Quality Indicators (PRWEQIs) through a sample of university students who carry out their academic activities remotely. Through the administration of a pool of items, an Exploratory Factor Analysis (EFA) will be carried out to select the most representative items and analyze the factorial structure of the instrument. The objective of the second study is to confirm the factorial structure of PRWEQIs through confirmatory factor analysis (CFA) on a sample of remote workers. Configural, metric, and scalar invariance will be tested through a multigroup CFA. In general, similarly to what has been done in other contexts, such as neighborhoods [72–74] and hospitals [75,76], the aim is to develop a measuring instrument that can return an indicator of the perceived environmental quality that can be related to indicators of occupational and organizational well-being in the remote work context.

## 2. Study 1

The objective of Study 1 is to analyze the initial composition of Perceived Remote Workplace Environment Quality Indicators (PRWEQIs) on a sample of Italian students engaged in remote studying. An exploratory factor analysis (EFA) was conducted to analyze the scale structure, describing the total covariance across a set of variables (the observed responses to scale items) based on a smaller number of unobserved variables directly, called factors.

### 2.1. Materials and Methods

#### 2.1.1. Participants and Procedure

During April 2021, 521 students from different Italian universities and degree courses were asked to fill in an online questionnaire (through a snowball method using the Qualtrics platform). The sample was gender balanced, with 266 men (51.1%) and 248 women (47.6%) (1.3% of participants preferred not to answer), with a mean age of 21 years (min: 18; max: 31; SD = 2.04). A total of 456 students were enrolled in a first-level or single-cycle degree (87.5%), and 65 (12.5%) in a second-level degree. The research was conducted in full compliance with the Ethical Principles of Psychologists and Code of Conduct of the American Psychological Association (APA) and in accordance with the Declaration of Helsinki and was authorized by the Ethics Committee of the Sapienza University of Rome (approval number 0000408, dated 7 April 2021). All participants were asked to think about the environment where, during the first semester of the 2020–2021 academic year (in Italy characterized by the implementation of distance learning due to the COVID-19 pandemic), most of the time they carried out their study activities remotely (attend lectures, participate in workshops, study, etc.). They were then asked to complete an online survey (through the Qualtrics platform) containing the first version of the PRWEQIs, followed by socio-demographic information.

#### 2.1.2. Measures

To identify the physical-spatial and ergonomic dimensions of the most significant impacts to be adapted into the development of the instrument, we turned to two expert architects who gave their opinion on which physical elements of the environment deserved more attention. Thanks to the advice of the experts, classes of needs have been identified, such as those of Safety, Well-being, Usability, Appearance, and Management, as defined by the UNI 8289: 1981 standard “Construction, end-user needs, classification.” Having identified the ergonomic dimensions to focus on, we built the first version of the Perceived Remote Working Environment Quality Indicators (PRWEQIs), consisting of 20 total items,

with a response scale in the form of a 5-point Likert scale, from “strongly disagree” to “strongly agree”.

## 2.2. Results

The data analysis was carried out using the Jamovi software v.2.2.5. Preliminarily, the Kaiser–Meyer–Olkin Measure of Sampling Adequacy and Bartlett’s Test of Sphericity were conducted. The results of the KMO (0.867) and Bartlett’s test ( $\chi^2_{(190)} = 5666.55, p < 0.001$ ) confirm the suitability of the data for factor analysis [77]. To evaluate the factorial composition of the initial 20 items, an exploratory factor analysis was conducted with the principal axis as the Oblimin extraction and rotation method. Concerning the Kaiser criterion (eigenvalue > 1) and the analysis of the scree plot, the indications of Costello and Osborne [78] have been followed, and the items that have either low loadings (<0.30) or cross-loaded (>0.30 on more than one factor), have been eliminated. Five factors emerged from the first extraction results with eigenvalues greater than 1. In this first solution, however, five items were eliminated as they reported factor loadings of less than 0.30 or excessive cross-loadings on more than one factor. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy for the 15-item solution was 0.828, above the commonly recommended value of 0.600 [79]. Bartlett’s Test of Sphericity was also significant ( $\chi^2_{(105)} = 4718.25, p < 0.001$ ). The 15-item model split over five factors (three items per factor) accounted for 68.26% of the variance among the items. Factor loadings are presented in Table 1. Cronbach’s alpha for all scales ranged from 0.95 to 0.78, representing a sufficient index of the reliability of the measurements [80].

**Table 1.** Results from an Exploratory Factor Analysis (EFA) of the Perceived remote workplace environmental quality indicators (PRWEQIs).

Perceived Remote Workplace Environmental Quality Indicators	Factor Loading				
	1	2	3	4	5
<b>Factor 1: Acoustic comfort</b>					
8. The room where I work is quiet enough	<b>0.97</b>	−0.01	−0.07	0.03	0.03
3. In this room, noises can be heard coming from other areas of the house/environment (R)	<b>0.92</b>	0.01	0.04	−0.01	−0.01
13. In this room, I can hear noises coming from outside (R)	<b>0.90</b>	0.00	0.04	−0.02	−0.02
<b>Factor 2: Visual comfort</b>					
14. That workstation is well-lit during the day	0.02	<b>0.86</b>	0.03	−0.02	0.02
1. I am satisfied with the lighting in this room	0.06	<b>0.86</b>	−0.03	0.02	0.00
15. In this room during the day, there is enough natural light	−0.08	<b>0.85</b>	0.01	0.00	0.00
<b>Factor 3: Quality of furnishing</b>					
5. The furniture in this room is well-made	0.01	0.03	<b>0.77</b>	0.01	−0.05
4. The surfaces of the furnishings of the workstation are well-made and resistant to wear	0.02	0.00	<b>0.74</b>	0.03	0.04
2. The furnishings in this room are in good condition	−0.01	−0.01	<b>0.74</b>	0.01	0.05
<b>Factor 4: Safety</b>					
12. In this room, I can move safely	−0.01	0.05	0.02	<b>0.84</b>	−0.04
6. In this room, I can move without bumping into anything	0.07	0.01	−0.07	<b>0.74</b>	0.01
11. I can move freely in that room	−0.03	−0.06	0.15	<b>0.64</b>	0.12
<b>Factor 5: Space usability</b>					
7. In this workstation, I have all the equipment necessary for the work activity at hand	−0.05	0.01	−0.06	0.09	<b>0.79</b>
10. I am satisfied with the equipment I have available in this workstation for my work activity	0.04	0.03	0.06	−0.10	<b>0.77</b>
9. In this workstation, I can carry out my work activity comfortably	0.10	0.02	0.13	0.14	<b>0.51</b>
Alpha	0.95	0.90	0.81	0.80	0.78

Note: Principal axis factoring extraction method was used in combination with a “Direct Oblimin” rotation. N = 521. The extraction method was principal axis factoring with an oblique (Direct Oblimin with Kaiser Normalization) rotation. Factor loadings above 0.30 are in bold. Reverse-scored items are denoted with an (R). The 5-factor model explains 68% of the total variance.



Factor 1 (Acoustic comfort; Alpha = 0.95) represents the noise perception in the environment used for remote work activity, both in terms of noise from outside the environment and from other areas of the house/environment.

Factor 2 (Visual comfort; Alpha = 0.90) concerns the perception and evaluation of the lighting quality in the work area. Specifically, one item assesses the presence/absence of sufficient natural light from outside.

Factor 3 (Quality of the furnishing; Alpha = 0.81) focuses on the quality and wear resistance of the materials used in the workplace.

Factor 4 (Safety; Alpha = 0.80) represents the perception of safety experienced by the worker within the environment of being able to move freely without incurring impediments or injuries.

Finally, factor 5 (Space usability; Alpha = 0.78) indicates the perception of usability of the workspace, where the worker can comfortably carry out his work activity with all the necessary equipment close at hand. The correlations between the five factors are shown in Table 2.

**Table 2.** Inter-factor correlation for Study 2.

	F1	F2	F3	F4	F5
F1—Acoustic comfort	—	0.18	0.18	0.25	0.22
F2—Visual comfort		—	0.34	0.32	0.33
F3—Quality of furnishing			—	0.45	0.50
F4—Safety				—	0.47
F5—Space usability					—

### 2.3. Discussion

The main objective of Study 1 was to analyze a first factorial composition of the items of the scale called Perceived Remote Working Environment Quality Indicators (PRWEQIs). According to the guidelines of Sakaluk and Short [81], the sample was sufficiently large to perform an Exploratory Factor Analysis (EFA). Starting from a set of 20 items, deriving from an ergonomic and objective assessment checklist of the work environment (UNI 8289: 1981), we obtained a first-scale solution of 15 items that best represented the environmental and comfort elements in the remote study context. In the final solution that emerged from the Exploratory Factor Analysis, the 15 items were distributed over five factors (three items per factor). The five factors that emerged represent some of the environmental aspects most reported in similar measuring instruments [72,75] and which impact the worker's well-being [51], namely Acoustic comfort, whose items refer to the acoustic perception of noises coming from inside or outside the study environment; Visual comfort, referring to the quality of natural and artificial lighting available in the setting; Quality of the furnishing, concerning the materials and surfaces used for the study activity; Safety, with items referring to the perception of the safety of movement within the space; and Spaceusability, with aspects concerning the management of the equipment necessary to complete the study activity. The scale has been shown to have good psychometric properties, with the five factors that, taken together, explain 68% of the total variance. The five factors also reported excellent indexes of reliability and inter-correlation between the items (Alpha between 0.95 and 0.78), thus allowing a specific use of the individual factors for the analysis of specific environmental elements. Study 1 made it possible to create a first specific indicator for studying the perception of comfort in the remote study environment. The tool can be used to study those elements that can have a positive impact on students' psychological well-being and performance. The structure that emerged in Study 1, however, needs to be confirmed by confirmatory factor analysis (CFA). Despite the similarities between students engaged in e-learning activities and remote workers, extending the results to a population of workers employed in remote work activities is essential, given the object of the scale.

### 3. Study 2

The objective of the second study is to confirm or disconfirm the factorial structure that emerged from Study 1 and to externalize its validity to a sample of remote workers. To evaluate the factorial structure of the PRWEQIs, a confirmatory factor analysis (CFA) was used to compare three alternative models (i.e., single-factor model, five-factor model, and five-factor model with second-order factor). Then the invariance of the scale, the evaluation of the equivalence of the measure on different groups, specifically on the gender of the participants, will be tested.

#### 3.1. Materials and Methods

##### Participants, Procedure, and Measures

For the second study, a sample of 463 Italian workers in public and private sectors was recruited with clerical jobs and who, at the time of administration (October 2021), worked remotely, with an average age of 35 years (min = 18; max = 64; SD = 10.37) and average organizational seniority of 7.36 years (min = 1; max = 40; SD = 8.62). From the initial sample, the few participants who indicated that they carried out their remote work activity from environments outside the home (e.g., coworking, bars, restaurants) were eliminated. The sample was divided into 266 men (57.5%) and 197 women (42.5%). Research participants were recruited through the Prolific platform and within a private organization operating in the banking sector. The research was conducted in full compliance with the Ethical Principles of Psychologists and Code of Conduct of the American Psychological Association (APA) and in accordance with the Declaration of Helsinki and was authorized by the Ethics Committee of the Sapienza University of Rome (approval number 0001299, dated 20 October 2021). They were then asked to fill out an online survey (through the Qualtrics platform) containing the following measures:

Perceived Remote Workplace Environment Quality Indicators (PRWEQIs): the scale was administered in the 15-item solution that emerged from Study 1.

Work Engagement: the Utrecht Work Engagement Scale Short Version (UWES-9) [81] in its Italian validation [82] was used, composed of 9 items (Alpha = 0.86; e.g., “*At my job, I feel strong and vigorous*”).

Perceived Stress: the Perceived Stress Scale [83,84], in its short 4-item version in its Italian validation [85] was used to evaluate the perception of work-related stress during remote working activity (Alpha = 0.75; e.g., “*Difficulties were piling up so high that you could not overcome them?*”).

Remote Job Satisfaction: the 3 items are derived from the scale of Job satisfaction [86], in their adaptation to remote working [87] (Alpha = 0.89; e.g., “*Once the emergency is over, if I had to decide to work remotely again, I would choose it*”).

A 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) was used for all measures. Socio-demographic questions were inserted at the end of the questionnaire.

#### 3.2. Results

Considering the small number of indicators per factor, the sample recruited is sufficiently adequate to perform the confirmatory factor analysis [88–91]. The analyses of the alternative models and the invariance were conducted using Mplus v.8 [92]. To evaluate the adequacy of the fit of the models, several indices were examined. The score obtained in these indicators represents an index of goodness of fit of the model, comparable with the cut-offs: the ratio between  $\chi^2$  and degrees of freedom between 0 and 3, comparative fit index (CFI)  $\geq 0.95$ , standardized root mean square residual (SRMR)  $\leq 0.10$  and the root mean square error of approximation (RMSEA)  $\leq 0.08$  are symptoms of an acceptable model fit [93]. The chi-square test has not been evaluated due to its known sensitivity to sample size [89,94]. The CFA was performed on the 15 items emerging from Study 1, testing three alternative models: a single-factor model (model A), a model with five correlated factors (model B), and a model with five first-order factors and one second-order factor (model C), called “General perceived comfort” (Table 3).

**Table 3.** CFA for Perceived Remote Workplace Environment Quality Indicators (PRWEQIs).

PRWEQIs	$\chi^2$	df	p	$\chi^2/df$	CFI	SRMR	RMSEA [90% CI]
Model A: 1-Factor Model	2513	90	<0.001	27.922	0.419	0.139	0.241 [0.233, 0.249]
Model B: 5-Factor Model	139.08	80	<0.001	1.739	0.986	0.040	0.040 [0.029, 0.051]
Model C: 5-Factor Model + 1 second-order factor	143.89	85	<0.001	1.693	0.986	0.043	0.040 [0.027, 0.049]

Note: CFI = comparative fit index; NNFI = (Non) Normed Fit Index; SRMR = (Standardized) Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation.

The results show that only models B and C reported satisfactory fit indices, confirming the results of Study 1. The model with only one general factor did not, on the contrary, obtain acceptable fit indices for any indicator. To compare the two remaining alternative models (parameter nested), a test of the chi-squared difference between the more restrictive model (model C) and the less restrictive one (model B) was performed. Since the test was not significant, we can consider the more restrictive model (model C) as the one that fits the data better ( $\Delta\chi^2 = 4.81$ ;  $\Delta df = 5$ ;  $p = 0.44$ ). The five first-order factors and the second-order factor reported satisfactory reliability indices (Acoustic comfort: Alpha = 0.95; Visual comfort: Alpha = 0.84; Quality of the furnishing: Alpha = 0.86; Safety: Alpha = 0.79; Space usability: Alpha = 0.84; General perceived comfort: Alpha = 0.87). The correlations between the five factors are shown in Table 4.

**Table 4.** Inter-factor correlation for Study 2.

	F1	F2	F3	F4	F5
F1—Acoustic comfort	—	0.24	0.31	0.22	0.29
F2—Visual comfort		—	0.34	0.37	0.41
F3—Quality of furnishing			—	0.37	0.40
F4—Safety				—	0.44
F5—Space usability					—

To evaluate the strength of the structure of model C, a series of analyses were conducted to assess the invariance between groups. Specifically, the invariances on gender (1 = M; 2 = F) were tested through a multistage procedure in the framework of multiple-group confirmatory factor analysis (MGCFA) [95]. In the context of remote working, gender has assumed a fundamental role in promoting well-being and remote job satisfaction [96,97]. One of the main gender-related issues concerns household management and family care, a role that, historically, in Western cultures has been entrusted to women. This different subdivision of domestic activity could lead to differences in the perception of comfort during remote working activity, resulting in different functioning of the scale for men and women. The procedure is based on a chi-square difference test between two nested models: a constrained model (where invariance is assumed) and an unconstrained model (where no invariance is assumed). Since, as reported previously, the chi-squared difference test is sensitive to sample size, the test will be accompanied by the analysis of the difference in CFI ( $\Delta CFI$ ), an index less sensitive to this type of problem [98]. The sample was balanced enough to test the invariance of the scale on gender (M = 266; F = 197). According to Kline [89] and Wang and Wang [99], 100 participants per group are sufficient for a multigroup CFA. As suggested by Dimitrov [100], to test the configural invariance, the second-order model was tested on the two groups separately. Table 5 shows that the fit indices are satisfactory for both groups (men and women), confirming the configurational invariance of the PRWEQIs. Given the complex nature of structures with higher-order factors, a series of comparisons between nested models is necessary for calculating invariance [100–102].



**Table 5.** Configural Invariance of the Second-Order CFA Model of Perceived Remote Workplace Environment Quality Indicators (PRWEQIs) across Gender.

Group	$\chi^2$	df	p	$\chi^2/df$	CFI	SRMR	RMSEA [90% CI]
1 = Male	106.24	85	<0.001	1.25	0.984	0.055	0.042 [0.018, 0.06]
2 = Female	135.81	85	<0.001	1.60	0.979	0.055	0.047 [0.032, 0.062]

Note: CFI = comparative fit index; NNFI = (Non) Normed Fit Index; SRMR = (Standardized) Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation.

Comparisons between the models used for calculating metric (each item similarly contributes to the latent construct), scalar (all mean differences in the shared variance of the items are captured by the latent construct's mean differences), and residual invariance (describe the variance in a model that the model's variables cannot explain), are presented in Table 6. Model 0, in which all model parameters are freely estimated, will be used as the baseline model. The intensity of the relationship between the items and the factors being comparable across groups is known as metric (or weak) invariance [103]: model 1 will have as a constraint the invariance of the loadings of the first-order factors (M1 – M0:  $\Delta\text{CFI} = -0.003$ ); in model 2 the constraints will be fixed for the invariance of the loadings of both the first-order and second-order factors (M2 – M1:  $\Delta\text{CFI} = 0$ ). The scalar (or strong) invariance is estimated by forcing the factor loadings and intercepts of the items to be equal in the two groups [98]. In model 3, the factor loadings of the first and second-order factors and intercepts of the items are set as invariants (M3 – M2:  $\Delta\text{CFI} = -0.003$ ); in model 4 the intercepts of the first-order factors will be added (M4 – M3:  $\Delta\text{CFI} = 0$ ). Finally, the error or residual variance imposes additional constraints on the measurement residuals, both the uniquenesses of indicators and disturbances of first-order factors. Model 5 is set to the previous one, forcing first-order factor disturbances (M5 – M4:  $\Delta\text{CFI} = -0.002$ ); model 6 adds the constraint to the item uniqueness (equal variance and covariance between the two groups) (M6 – M5:  $\Delta\text{CFI} = -0.009$ ).

**Table 6.** Testing for Factorial Invariance of a Second-Order Factor Model of PRWEQIs Across Two Groups (Gender).

Model	$\chi^2$	df	Comparison	$\Delta\chi^2$	$\Delta df$	CFI	$\Delta\text{CFI}$	RMSEA
M0	250.012	170	-	-	-	0.981	-	0.045
M1	272.798	180	M1-M0	22.786	10	0.978	-0.003	0.047
M2	276.181	184	M2-M1	3.383	4	0.978	0	0.047
M3	303.644	198	M3-M2	27.463	14	0.975	-0.003	0.048
M4	304.449	199	M4-M3	0.805	1	0.975	0	0.048
M5	319.069	204	M5-M4	14.62	5	0.973	-0.002	0.049
M6	369.765	219	M6-M5	50.696	15	0.964	-0.009	0.055

Note: CFI = comparative fit index; RMSEA = root mean square error of approximation; M0 = baseline model (without invariance); M1 = first-order factor loadings invariant; M2 = first-order and second-order factor loadings invariant; M3 = first-order and second-order factor loadings and item intercepts invariant; M4 = first-order and second-order factor loadings, item intercepts, and first-order factor intercepts invariant; M5 = first-order and second-order factor loadings, indicator intercepts, first-order factor intercepts, and first-order factor disturbances invariant; M6 = first-order and second-order factor loadings, indicator intercepts, first-order factor intercepts, first-order factor disturbances, and item residual variances invariant.

Once the invariance of the measure on gender was established, a series of multiple linear regressions were conducted to establish the effect of single factors on measures of work-related psychological well-being. The general comfort factor was found to be significantly correlated with Work Engagement ( $r = 0.41$ ;  $p < 0.001$ ), Perceived Stress ( $r = -0.42$ ;  $p < 0.001$ ), and Remote Job Satisfaction ( $r = 0.28$ ;  $p < 0.001$ ). From the results emerging from the analysis of the regressions between the five factors of the PRWEQIs and the three psychological variables (Table 7), it is possible to highlight how the ergonomic-spatial elements have a different effect on different outcomes of work-related well-being. In particular, Work Engagement was positively influenced by the factors “Quality of

furnishing" ( $\beta = 0.22$ ;  $p < 0.001$ ) and "Space usability" ( $\beta = 0.16$ ;  $p < 0.01$ ); the environmental elements with a greater effect of prevention against stress symptoms were found to be "Acoustic comfort" ( $\beta = -0.15$ ;  $p < 0.001$ ), "Quality of furnishing" ( $\beta = -0.16$ ;  $p < 0.001$ ), and "Safety" ( $\beta = -0.15$ ;  $p < 0.01$ ); finally, "Visual comfort" ( $\beta = 0.12$ ;  $p < 0.05$ ) and "Space usability" ( $\beta = 0.22$ ;  $p < 0.001$ ) had a positive effect in promoting remote job satisfaction.

**Table 7.** Linear regression.

Effect for Work Engagement	Estimate	SE	95% CI		p
			LL	UL	
Intercept	3.60	0.03	3.55	3.66	<0.001
F1—Acoustic comfort	0.05	0.03	−0.01	0.01	0.11
F2—Visual comfort	0.07	0.04	−0.01	0.15	0.07
F3—Quality of furnishing	0.20	0.04	0.11	0.28	<0.001
F4—Safety	0.07	0.05	−0.03	0.16	0.19
F5—Space usability	0.15	0.05	0.06	0.24	<0.01
Gender	0.06	0.06	−0.06	0.17	0.34
R <sup>2</sup>	0.19				

  

Effect for Perceived Stress	Estimate	SE	95% CI		p
			LL	UL	
Intercept	2.41	0.03	2.35	2.47	<0.001
F1—Acoustic comfort	−0.10	0.03	−0.16	−0.04	<0.001
F2—Visual comfort	−0.08	0.04	−0.16	0.01	0.08
F3—Quality of furnishing	−0.16	0.05	−0.25	−0.06	<0.001
F4—Safety	−0.17	0.05	−0.28	−0.06	<0.01
F5—Space usability	−0.05	0.05	−0.15	0.04	0.28
Gender	0.13	0.06	0.01	0.25	<0.05
R <sup>2</sup>	0.19				

  

Effect for Remote Job Satisfaction	Estimate	SE	95% CI		p
			LL	UL	
Intercept	4.26	0.04	4.19	4.33	<0.001
F1—Acoustic comfort	0.01	0.04	−0.08	0.06	0.80
F2—Visual comfort	0.11	0.05	0.02	0.21	<0.05
F3—Quality of furnishing	0.03	0.06	−0.08	0.14	0.62
F4—Safety	0.06	0.06	−0.06	0.18	0.31
F5—Space usability	0.23	0.06	0.12	0.35	<0.001
Gender	−0.01	0.07	−0.15	0.12	0.85
R <sup>2</sup>	0.11				

Note. N = 463; CI = confidence interval; LL = lower limit; UL = upper limit.

Finally, to assess any differences based on socio-demographic variables (gender, age, and educational attainment) in the scores of the five factors and on the aggregate one, a series of multivariate analyses of variance (MANOVA) was conducted. The analysis did not reveal any statistically significant differences based on gender, age, or level of education.

### 3.3. Discussion

The objective of the second study was fully achieved. From the analysis of the CFA, the factor structure emerging from Study 1 was widely confirmed. The structure of the 15 items, divided into five factors, namely Acoustic comfort, Visual comfort, Quality of the furnishing, Safety, and Space usability, emerged in the sample of Italian e-learning students, was confirmed for a sample of remote workers. The results arising from the CFA have also made it possible to identify a second-order factor, referring to the general comfort perceived in the environment. This factor is, therefore, the summary of the specific elements previously identified, starting from the consultancy of experts in the field of ergonomics applied to the workplace. PRWEQIs have been shown to have a good psychometric

structure, as confirmed by the excellent fit indexes of the model. Furthermore, in this case the five first-order factors and the second-order factor reported excellent reliability indexes (Alpha between 0.95 and 0.79). Multigroup CFA provided evidence on the invariance of the gender-based scale. The factorial structure of the scale is therefore confirmed for both men and women. As confirmed by the multivariate analysis of variance (MANOVAs), no statistically significant difference emerged in the scores of the five first-order factors and of the second-order factor based on the main socio-demographic characteristics (gender, age, and educational qualification). Finally, from the analysis of multiple regression, it was possible to analyze the effect of PRWEQIs on some variables of work-related psychological well-being. The perception of adequate environmental comfort in the setting of remote work positively influenced engagement and remote job satisfaction, consequently reducing the perception of work-related stress. This second study, therefore, made it possible to confirm the factor structure that emerged from Study 1, extending it and confirming it to remote workers, allowing the creation of a general indicator of comfort perceived during remote work, where the five first-order factors focus on specific environmental elements, allowing for a more generalized analysis, or to focus on specific elements of interest.

#### 4. Conclusions

Starting from objective indicators of the ergonomic qualities of workplaces, it was possible to develop an initial indicator for assessing the perception of the physical-spatial qualities of environments dedicated to remote work. The factorial structure of the PRWEQIs allowed the identification of those environmental dimensions most often found in the IEQ literature that previous research has shown to have the most significant impact on worker well-being, productivity, and satisfaction. These characteristics, which concern visual and acoustic comfort, the quality of furnishings and their usability in handling, and perceived safety in the space, can be found in the other indicators used for different contexts [72,73,76]. Quality of light, both artificial and natural, sounds and acoustic privacy, view of outdoor and natural environments, and ergonomic and functional features are among the elements with a more significant effect on psychological variables such as well-being, stress engagement, etc. [51]. Multigroup CFA allowed validation of the factorial structure of PRWEQIs on male and female remote workers. The analysis of multiple regressions confirmed the positive impact of perceived comfort in the workplace on various indicators of work-related well-being, such as engagement, job satisfaction, and perceived stress. According to the person–environment fit, each environment must adapt to the individual's characteristics and needs. COVID-19 has not only led to a forced migration from classic work environments to new environments, which can often overlap with the home environment, but has caused the restructuring of these environments, adapting them to the various work-related activities. Research has long highlighted the importance of the person–work environment fit and how physical-spatial elements can contribute to productivity and occupational and organizational well-being, both in offices [104–107] or other kinds of workplaces (such as hospitals and residential facilities) [108,109], and those environments dedicated to remote work [71,110]. Creating the first specific indicator for this type of context can be helpful for researchers interested in studying the consequences of the person–environment misfit. Even more, this evidence can help planners and employers pay particular attention to remote environments, contributing to creating ergonomic and sustainable environments adaptable to different job demands and capable of intercepting the needs of the worker. From an employer's point of view, a continuous and periodic assessment of remote workers' perceptions of the spatial and comfort qualities of their work settings can provide a first indicator of work-related psychological well-being. Knowing the characteristics of the work environment and any deficiencies can contribute to preventive interventions by organizations to prevent symptoms of work-related stress and/or physical or musculoskeletal deficits caused by poor ergonomic settings unsuitable for work. In the preliminary phases following the decision to adopt remote working, PRWEQIs, as happens in participatory design, can provide indications to workers and organizations

on which elements must be present for the construction of an ergonomic and supportive setting for the person as a whole work activity. From the point of view of scientific research, the use of PRWEQIs can contribute to extending the existing literature on the person–environment relationship and to the study of the effects of physical-spatial elements in promoting psychological well-being.

#### *Limitations and Future Research*

Given its exploratory nature on a theme still mostly absent from and overlooked by the literature, the research is not without some limits. Firstly, the PRWEQIs focus on the perception of those environmental qualities of the remote workplace. By their very nature, they are self-report measures sensitive to subjectivity, bias, and over- or underestimation. Furthermore, mainly due to the types of environments, it was impossible to involve ergonomic design experts in an objective evaluation to compare the objective and subjective data. Future research will aim to implement this type of measurement as well. The overlap between the working environment and the home environment, combined with this lack of objective data and information on the previous characteristics of the office, does not allow the generalizability of the results. This type of variable could undoubtedly affect the environment-satisfaction–well-being relationship. Other limitations concern the way data and samples are collected. Firstly, the data were collected when the COVID-19 pandemic was still present: in this context, the adoption of remote working was strongly encouraged, aimed at reducing infections, and not always autonomously chosen by the worker. Furthermore, part of the data was collected through the Prolific platform, making it impossible to cluster the participants based on the reference work contexts. The lack of similar measures also did not allow for a further assessment of convergent and divergent validity. Future research will have the task of evaluating any overlaps and comparing the effects of the perception of comfort in the context of remote work and that in traditional offices and workplaces. Finally, a cross-sectional approach was used for the research, which made it possible to evaluate the perception of environmental qualities at a given moment but not its evolution over time. To better study the person–environment fit, subsequent research will have to adopt a longitudinal approach, possibly combining self-report and objective measures. Subsequent research will aim to analyze which physical elements of the environment impact remote worker well-being, identifying intervention strategies for creating human-centered work environments.

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