

Zumtobel Research

Lighting quality perceived in offices

Phase 1 | Data Analysis Europe

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Every day, we encounter a huge variety of visual stimuli in the office. Perfect light is just as essential for handling the respective work task as is our health, motivation and productivity. Light influences various vital processes in the human organism in many ways – and accordingly also our physical and mental wellbeing.

The aim of the user study initiated by Zumtobel and implemented in cooperation with Fraunhofer IAO, is to describe the current lighting situation in offices at a global scale and against this background, to systematically record the specific needs of various user groups in different work scenarios.

The present interim result of the long-term study highlights the importance of office lighting and focuses on human needs – both as a factor creating immediate added value and in order to increase the attractiveness of working environments. Also to strengthen the employees' loyalty towards the company.

From the study results, architects, lighting designers and facility managers will find substantial data to increase their understanding of the different needs of various groups of employees. By doing this, they will be able to increase the perceived lighting quality to a much greater extent, beyond existing limits and standards in future lighting projects.

2 Abstract

People are increasingly put at the centre of contemporary office concepts. Architecture, interior design and lighting increasingly focus on the needs of office workers and their activities. In this context, the lighting in the office is of particular importance. The present study deals with the quality of office lighting as perceived by the user, and with the discrepancy between the actual situation and the users' preferences. It allows for specific design principles to be derived as a basis for effective lighting concepts that are adequate to users and activities, beyond existing standards and procedures.

The results of the study demonstrate considerable potential for improving lighting quality in the office: In the set of questions regarding layout of their workplace, as many as, 30 % of study participants indicated poor alignment of their workstation with respect to the window. 82 per cent of survey participants indicated that they prefer a lighting solution with combined direct/indirect components. However, only 38 per cent have this type of lighting solution in their workplace. Moreover, study participants who have direct/indirect lighting above their workstation have a much more positive assessment of their wellbeing than participants with purely direct lighting.

The study shows similarly significant results in assessing the lighting quality of the light sources used at the workstation. LEDs are most favourably rated by the survey participants.

As regards the preferences for colour temperatures in the office, these are distributed heterogeneously between 3,000K and 7,000K. However, the users' preference for the range between 4,000K and 5,000K is by far the most marked. Due to the uniform distribution, differentiation by the specific user groups does not make sense.

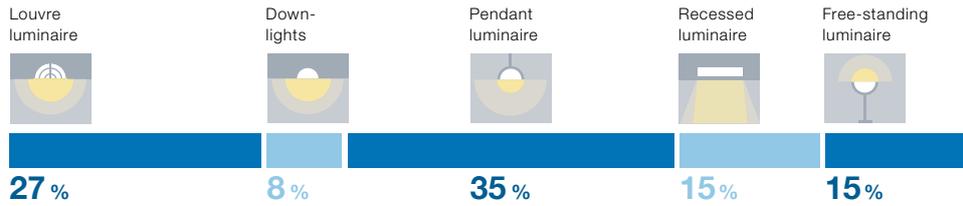
Almost 57 per cent of all employees stated that they are not able to adjust their office lighting to their individual needs and variable work settings, or are only able to do so to a limited extent. Restricted user access and insufficient options for adjustment correlate with a clearly poorer assessment of lighting quality and wellbeing. Study participants that are able to control their own lighting also had a higher assessment of their personal wellbeing.

What is remarkable: in the interactive part of the study, more than 60 per cent of survey participants chose illuminance levels of 800 lux or higher. This result exceeds the recommendations in the currently applicable standards and guidelines with their respective minimum levels for the lighting of computer workstations.

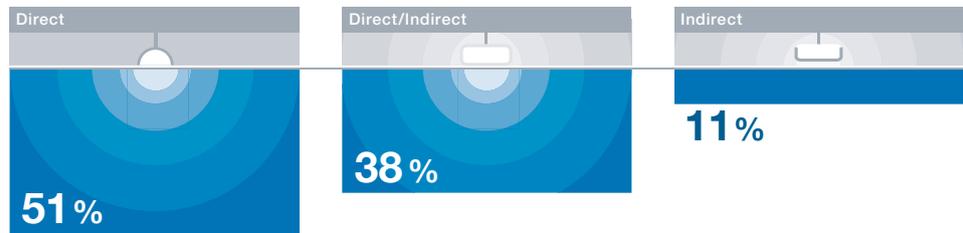
Independent of the season, the lighting remains constantly switched on in many offices throughout the day. 72 per cent of the study participants said that the lighting in their office is operated for in excess of six hours per day over winter time. Almost one third of the people surveyed said this is also true in spring and summer.

Failing to meet employee demands

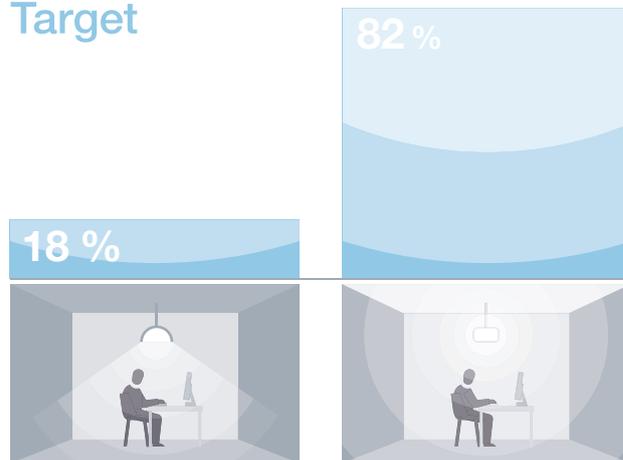
Light distribution patterns listed by frequency



Existing lighting listed by frequency



Actual vs Target



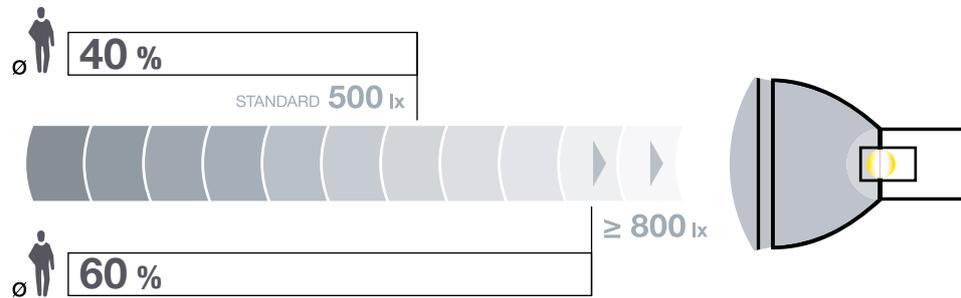
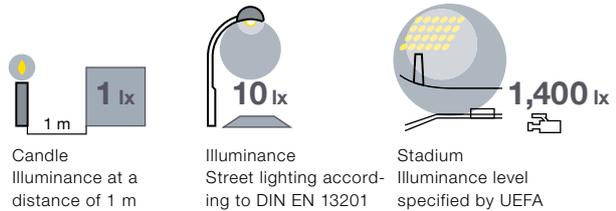
Combined benefits

In more than half of all offices (61.5 percent), only direct or indirect lighting is available. However, 82 percent of the participants surveyed prefer direct/indirect lighting solutions, with only 38.3 percent actually working in an office with this form of lighting distribution. Free-standing luminaires are only available to 15 percent of study participants, despite the fact that they are generally considered to enhance well-being.

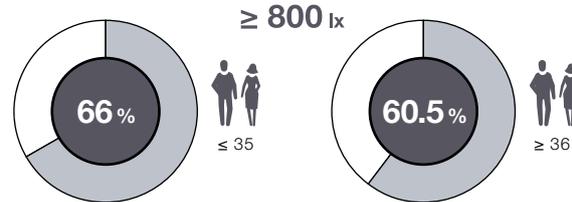
Illuminance

Preference for more light than stipulated by the norms

More than 60 percent of study participants prefer illuminance levels of 800 lx and higher. That means that the vast majority want illuminance levels markedly higher than required by the relevant standards.



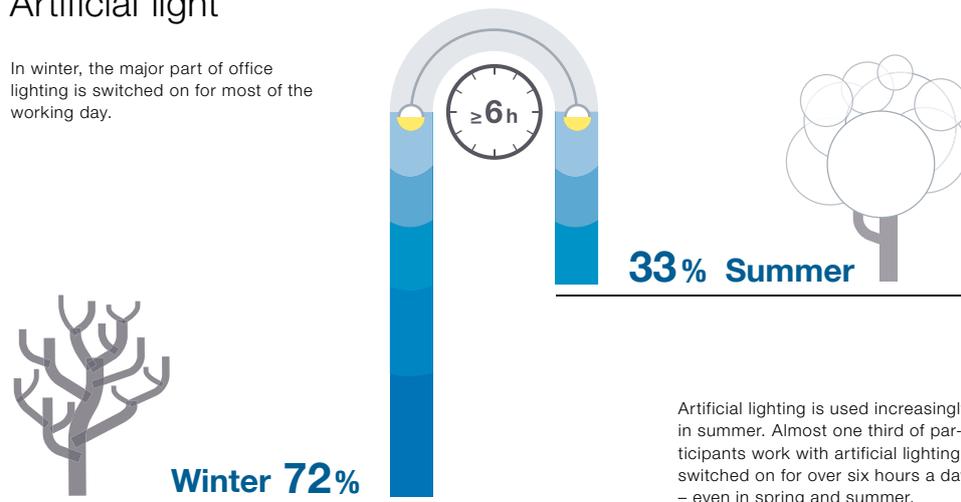
Whilst the survey only reveals minor differences between sexes, the desired illuminance levels vary markedly across various age groups. Younger people up to the age of 35 are shown to be the "most hungry for light".



Artificial light

Even in summer, there is a high demand for artificial light

In winter, the major part of office lighting is switched on for most of the working day.

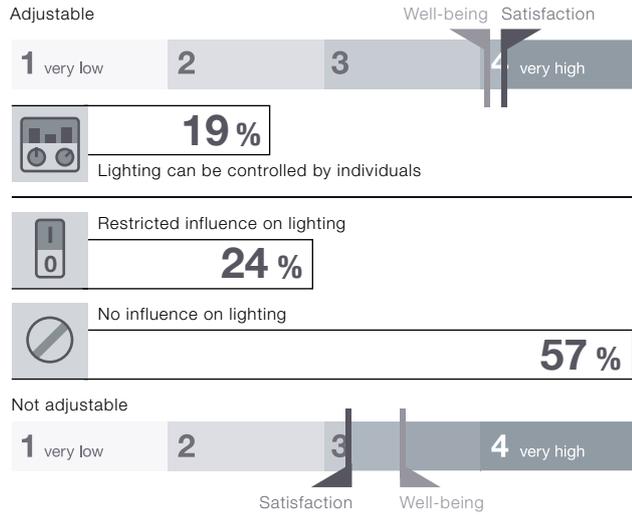


Artificial lighting is used increasingly in summer. Almost one third of participants work with artificial lighting switched on for over six hours a day – even in spring and summer.

Controllable lighting increases well-being

Adjustability

The survey revealed that very few of-fices offer employees the chance to adjust the lighting to meet their indi-vidual needs.
81 percent of survey participants re-ported limited or often no opportunity to control the lighting situation at their workplace.
However, the better the options to adjust the lighting, the more satisfied the employees are and the higher they rate their well-being.



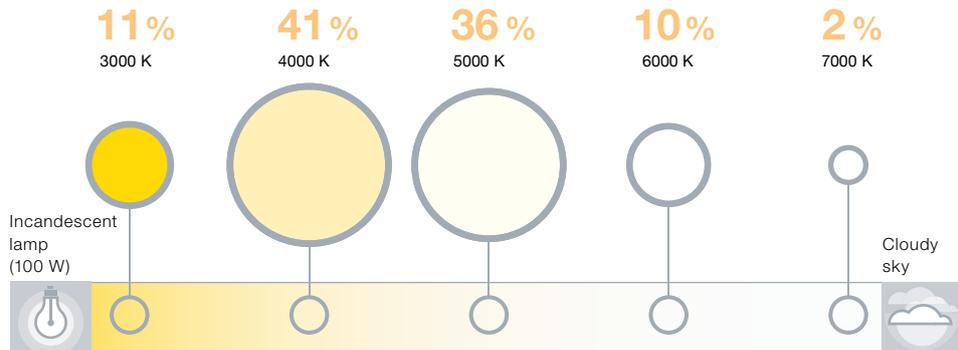
Flexible and efficient

Colour temperature

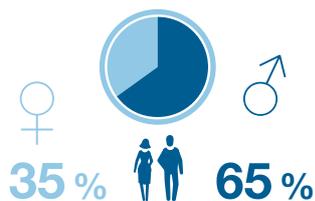
The results show that intermediate and warmer colour temperatures are generally more appreciated. In terms of age and sex, the tendencies are much less clear and rather empha-

size the generally heterogeneous distribution of colour temperature preferences between 3000 K and 7000 K, with two clear preferences clustered around 4000 K and 5000 K.

In practical terms, this means that flexible luminaires with variable colour temperatures should be used wherever possible.

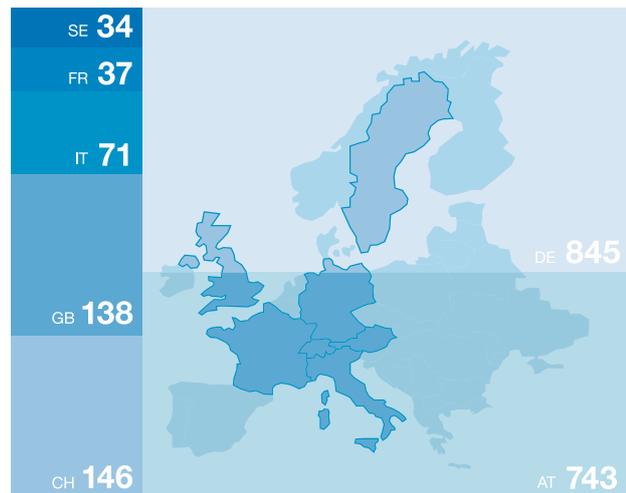


Survey



2014 participants from Europe

In terms of regional location, the majority of participants were based in Germany, Austria, Switzerland and the UK. The female:male percentage split was 35:65.



3 Problem definition

In a typical office scenario, the design and implementation of the lighting has been based so far, on standardised limits and minimum levels, e.g. for illuminance, luminance distribution or colour temperature. Moreover, ergonomic criteria such as glare control, contrast and light distribution are taken into account. Today, the user's preferences have only rarely served as a criterion informing the decision about the lighting installation – which was essentially due to the lack of fundamental research for potential standardisation. The present study is a survey dedicated to the preferences of users in general, trying to answer the following questions specifically:

- How is lighting quality assessed by office workers today, and what are the criteria influencing this assessment positively, as well as, negatively?
- Which quality features are of causative importance for a person's sense of wellbeing?

Since October 2013, the user study titled “The Light. Globale Nutzerstudie über die wahrgenommene Lichtqualität im Büro” (Global user study on lighting quality perceived at the office) has been available online (<http://www.zumtobel.web-erhebung.de/english/>). The survey format was chosen to address as many participants as possible.

The aim of the long-term study is to have users assess and choose, in a differentiated manner, both the lighting quality currently perceived and the preferred lighting quality in different office settings by means of a computer-aided multilingual questionnaire (German, English, French).

The structure and content of the survey are divided into five subject ranges (A–E) presented in Fig. 1. Normally, 10 to 15 minutes will suffice to answer the questions and provide the assessments.

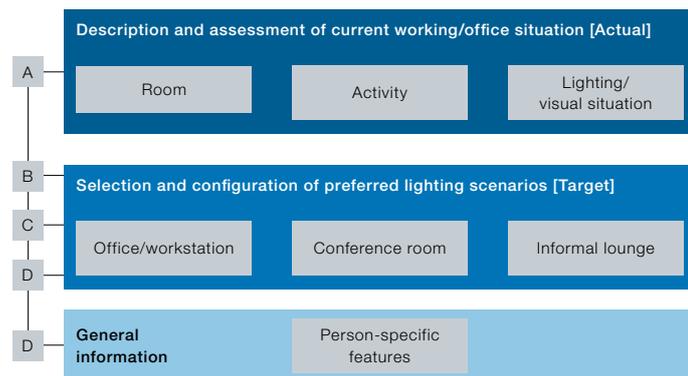


Figure 1:
Structure and subject ranges of the “Lighting quality perceived at the office” online survey

For the lighting scenarios surveyed in sets of questions B–D for office/workstation, meeting rooms and informal lounges, realistic renderings based on precise photometric calculations were prepared. To optimise the concept variant selected in each case, it was possible to continuously adjust the lighting scenario to the preferred brightness and colour temperature by means of sliders (visually analogue scale).

Different qualities of representation due to unevenly calibrated VDUs may be neglected in this case, provided there is a high N value and accordingly a largely neutralising normal distribution. The mean value of all data taken together (in case of high N and assumed normal distribution – e.g. regarding the individual adjustment of monitor brightness) remains the same and does not change in any significant way.

5 Results

5.1 General results/basic data

The present study is a long-term survey. The pertaining list of questions has been available online since 17 October 2013. The following results are based on an interim analysis of the data for Europe (Phase 1). This partial data set comprises the answers given by 2,148 participants as at 19 February 2014.

Participants

As regards regional origin, people from Germany (39 per cent), Austria (35 per cent), Switzerland (8 per cent) and Great Britain (6 per cent) have participated (Fig. 2); 35 per cent of the participants are female, 65 per cent are male.

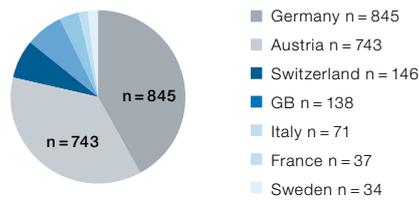


Figure 2:
The majority of the participants in Phase 1 of the survey are from Germany, Switzerland, Austria and Great Britain.

In terms of age structure, the distribution of the participants is in line with expectations (Fig. 3): The three medium age groups of 26- to 55-year olds constitute the majority with 27 and 29 per cent, respectively. People under 25 years of age and those older than 56 years account for 8 and 9 per cent, respectively.

Participants by age groups

Interim analysis Europe [n = 2,148]

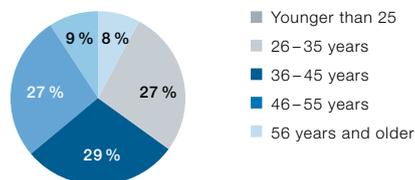


Figure 3:
The three medium age groups constitute the majority of participants.

On the other hand, actual presence in the office varies greatly, as shown in Figure 4: almost 69 per cent of participants regularly work at the office between 16 and 20 days per month.

Participants by days of work at the office per month

Interim data analysis Europe [n = 2,148]

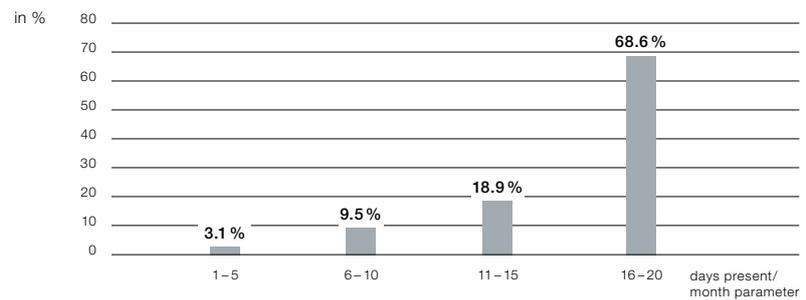


Figure 4:

Nearly 69 per cent of participants are present at the office for 16 to 20 days a month.

The activity profiles of the participants are also quite different. Overall, however, work at the computer prevails with close on 60 per cent (Fig. 5). In this context, 40 per cent of the survey participants state that they frequently experience eye fatigue after working at the PC for long hours (Fig. 6).

Participants by activity profile

Interim data analysis Europe [n = 2,148]

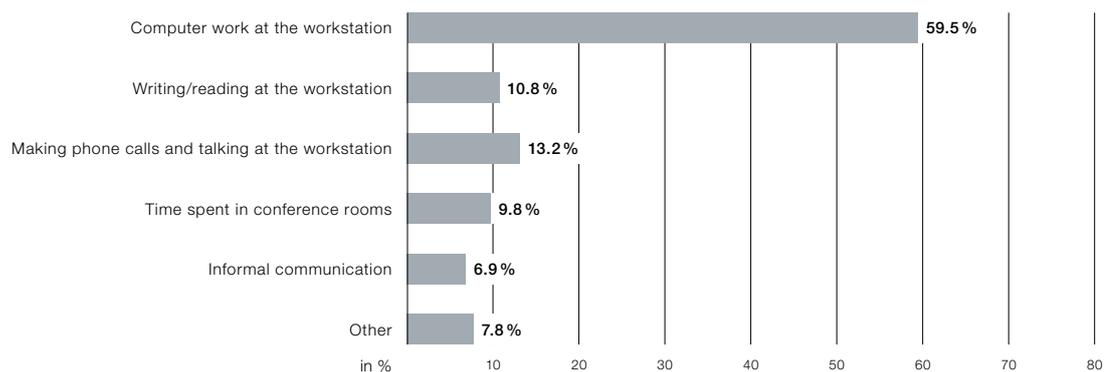


Figure 5:

Computer work dominates the activity profiles.

5 Results

Distribution "I don't experience eye strain even after working on my computer during prolonged periods."
Interim data analysis Europe [n = 2,148]

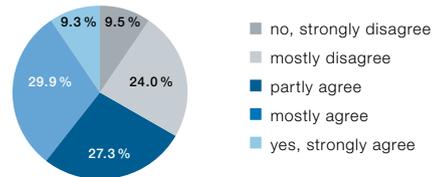


Figure 6:
40 per cent of survey participants indicate that their eyes get tired after prolonged VDU work.

5.2 Types of office and office layout

The types of office that are common at the moment present a fairly homogeneous picture: single-person offices, two- and multi-person offices, team offices as well as open-plan layouts are each represented with 14 to 23 per cent. Within flexible office concepts, a little more than 3 per cent of participants work at alternating workstations (Fig. 7).

Distribution by room/office layout

Interim data analysis Europe [n = 2,148]



Figure 7:

More than 46 per cent of participants work in team or open-plan offices.

As regards the office layout and the basic forms of desk arrangement, block-type arrangements are relatively common, accounting for 54 per cent. Free-standing individual desks account for 23 per cent. (Fig. 8).

Participants by layout types

Interim data analysis Europe [n = 2,148/valid 2,112]

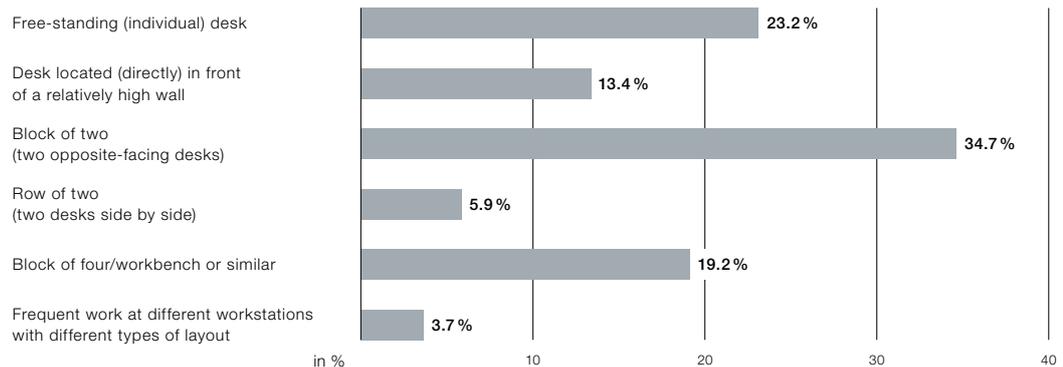


Figure 8:

Desk arrangements in blocks are frequent – 54 per cent.

5 Results

Under ergonomic aspects, computer workstations should ideally be arranged at right angles with respect to the windows. Figure 9 illustrates that this is the case with 70 per cent of study participants. It follows accordingly that the arrangement of 30 per cent of workstations is not ideal or even problematic.

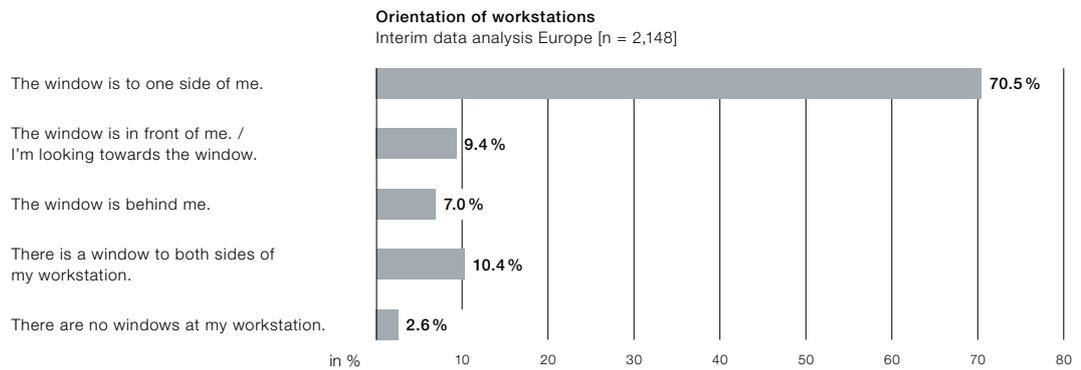


Figure 9:
More than 30 per cent of workstations are not ideally, or even poorly, arranged under ergonomic aspects.

According to the study results, employees with many years of experience frequently sit close to the windows (Fig. 10).

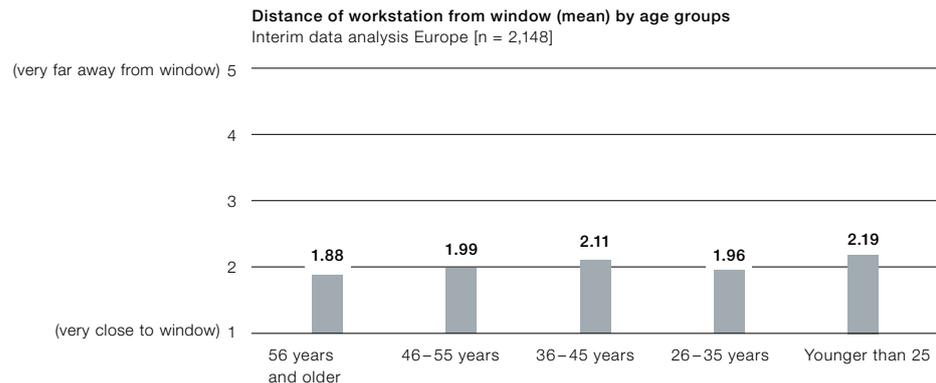


Figure 10:
From the age of 56 onwards, employees most frequently sit directly next to a window.

The comparison between age groups and office types also shows that younger employees frequently work in open-plan office layouts, while more senior colleagues often work in single- or two-person offices (Fig. 11).

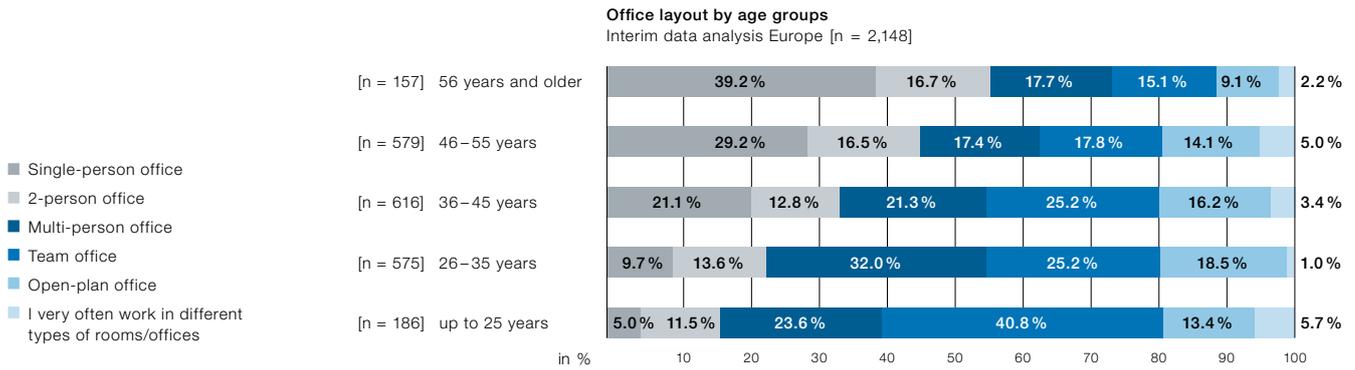


Figure 11:
More senior work teams work in office cubicles more frequently.

5 Results

5.3 Lighting situations

In more than half of all offices (50.6 per cent), only direct lighting is available (Fig. 12). However, 82 per cent of the participants surveyed prefer direct/indirect lighting solutions (Fig. 13), with only 38.3 per cent actually having such a lighting solution in place.

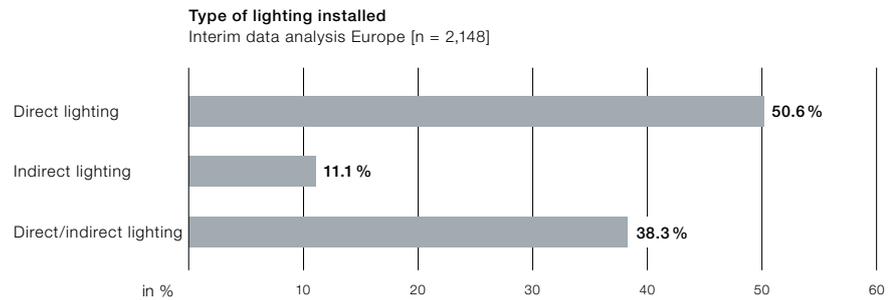


Figure 12:
Around 50 per cent of office workers currently work under purely direct lighting conditions.

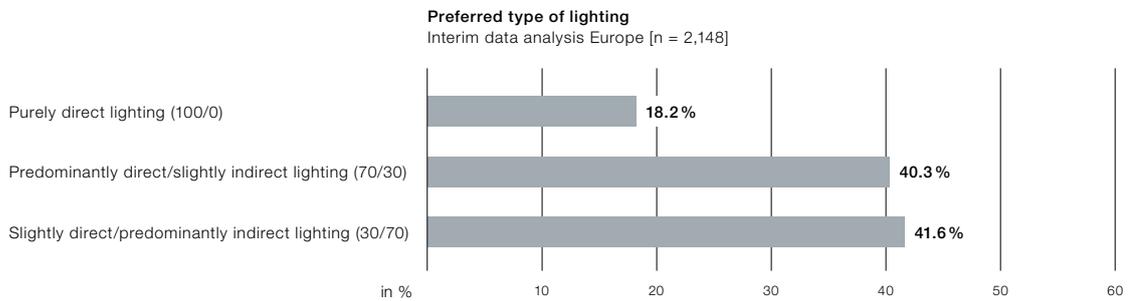


Figure 13:
Over 80 per cent prefer a direct/indirect lighting solution at the workstation.

Participants who have free-standing luminaires at their workstation assess their wellbeing clearly better (see Chapter 5.4). However, only 15 per cent of study participants (Fig. 14) have a free-standing luminaire at their workstation.

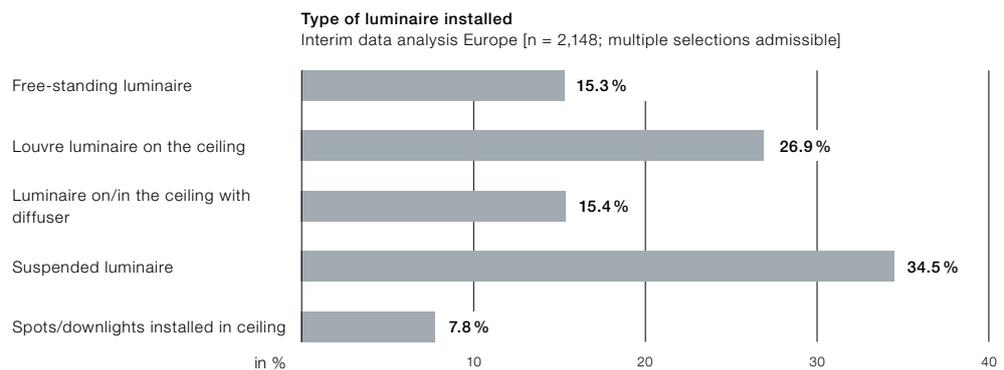


Figure 14:
With almost on 35 per cent, the proportion of suspended luminaires is highest.

Linear fluorescent lamps are the most frequent lamps used in offices. This light source is used in the case of 80 per cent of survey participants. LEDs are still rare (Fig. 15) at only 10 per cent usage – despite the fact that the lighting quality of LEDs clearly receives top ratings by the study participants (see Chapter 5.4).

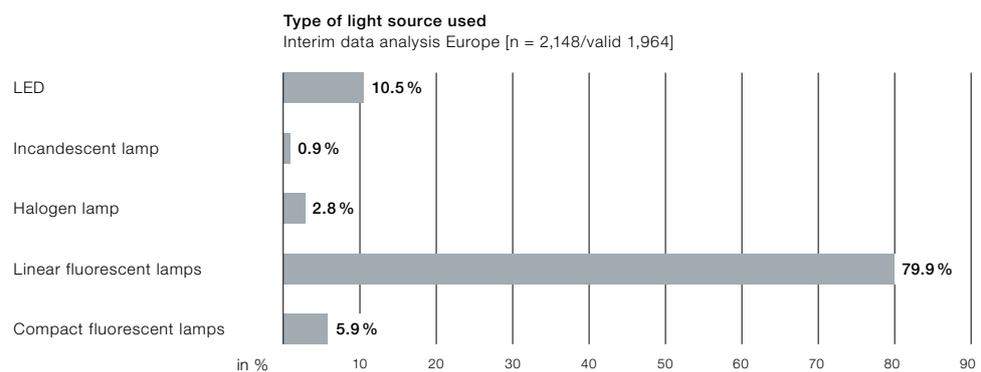


Figure 15:
With 10.5 per cent of survey participants, LEDs are used as a light source at the workplace.

5 Results

As regards power-on time, illustrated in Figures 16 and 17, the following was found: in winter, the main office lighting is on almost throughout the entire workday. Over 72 per cent of participants surveyed said that this is often for six hours or more per day, even in spring and summer, time where almost one third of study participants work said this was also the case.

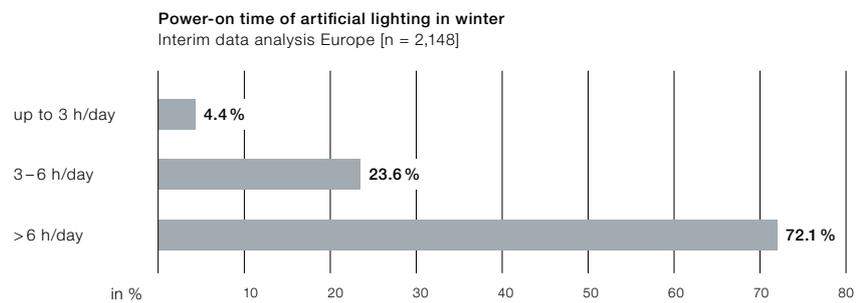


Figure 16:
For 72.1 per cent, the light is switched on for more than 6 hours a day in winter.

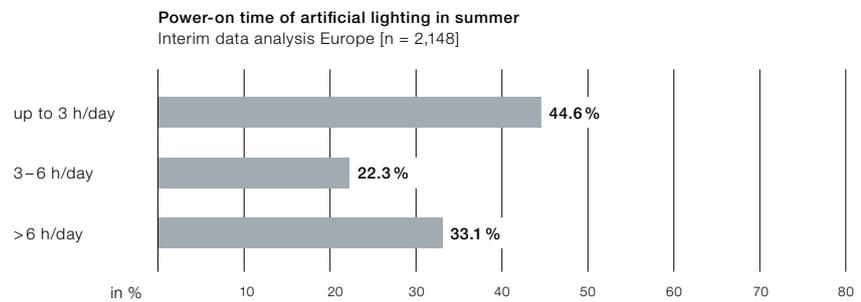


Figure 17:
One third of survey participants indicated that they use artificial lighting almost all day long even in summer.

5.4 Lighting quality and wellbeing

5.4.1 Colour temperature

The colour temperature of their office lighting in place is assessed as intermediate by 69.5 per cent of survey participants. On the other hand, 23.6 per cent assess the light colour of the existing lighting system to be “warm”, and 6.9 per cent think it is “cool” (Fig. 18). The survey results show that intermediate and warm light are perceived as more pleasant. In this context, the colour temperature perceived – from cool to warm – correlates with both an improved score for lighting quality, an increased sense of wellbeing and a higher satisfaction rating in terms of the general visual and lighting layout (Fig. 19).

Perceived colour temperature of the lighting

Interim analysis Europe [n = 2,148]

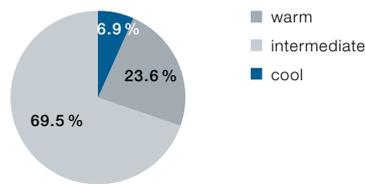


Figure 18: 93 per cent of participants work in lighting situations with intermediate or warm colour temperature.

Assessment of wellbeing, satisfaction and lighting quality according to perceived colour temperature.

Interim data analysis Europe [n = 2,148]

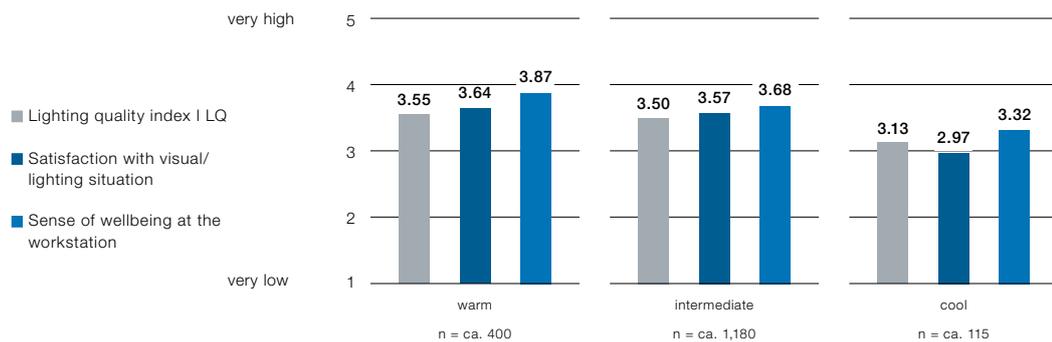


Figure 19: With intermediate and warm colour temperatures, wellbeing, satisfaction with respect to the visual/lighting situation and lighting quality receive higher ratings.

5 Results

Moreover, a correlation between the type of room and the preferred colour temperature can be seen (Fig. 20): in cellular and two person offices, preferences tend to favour warm and/or intermediate light, with the majority of users favouring 4,000K. In larger offices settings however, the majority of employees prefer a cooler lighter colour, the focus being around 5,000K.

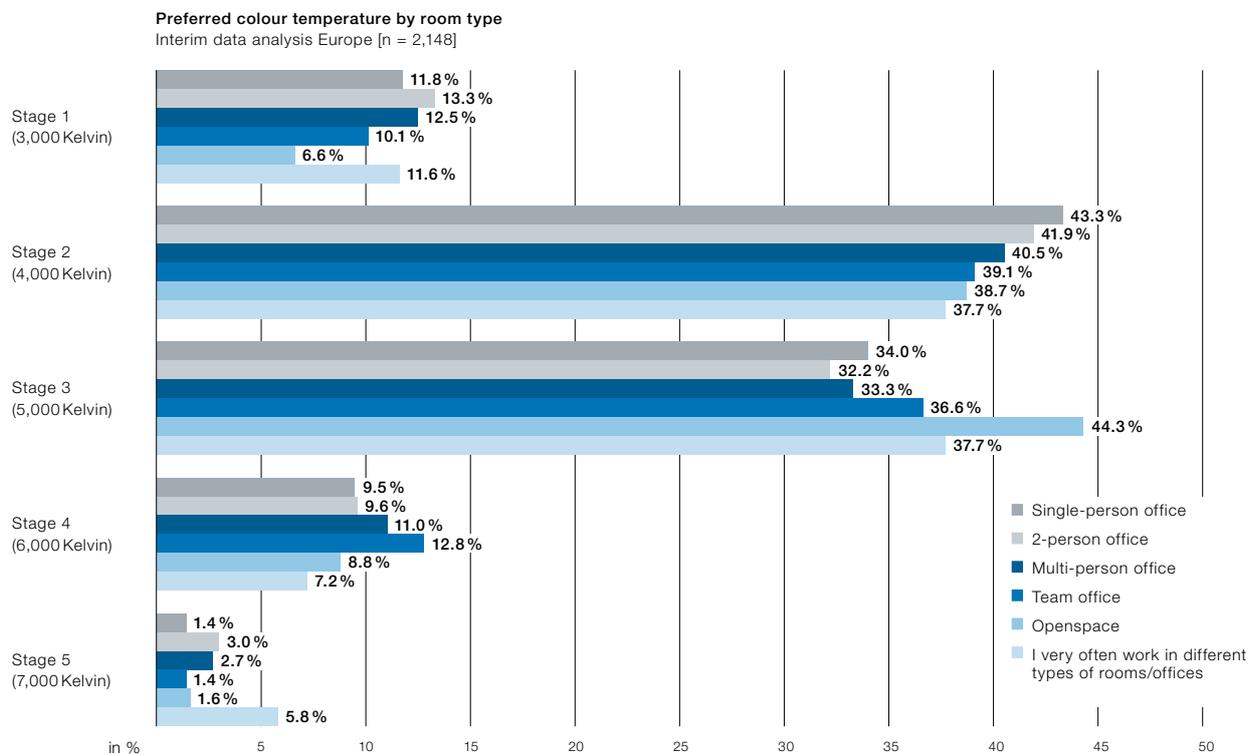


Figure 20:
The correlation between room type and preferred colour temperature is obvious.

In terms of age or sex, tendencies are much less clear and emphasises the generally heterogeneous distribution of colour temperature preferences between 3,000K and 7,000K, with focuses around 4,000K and 5,000K (Fig. 21).

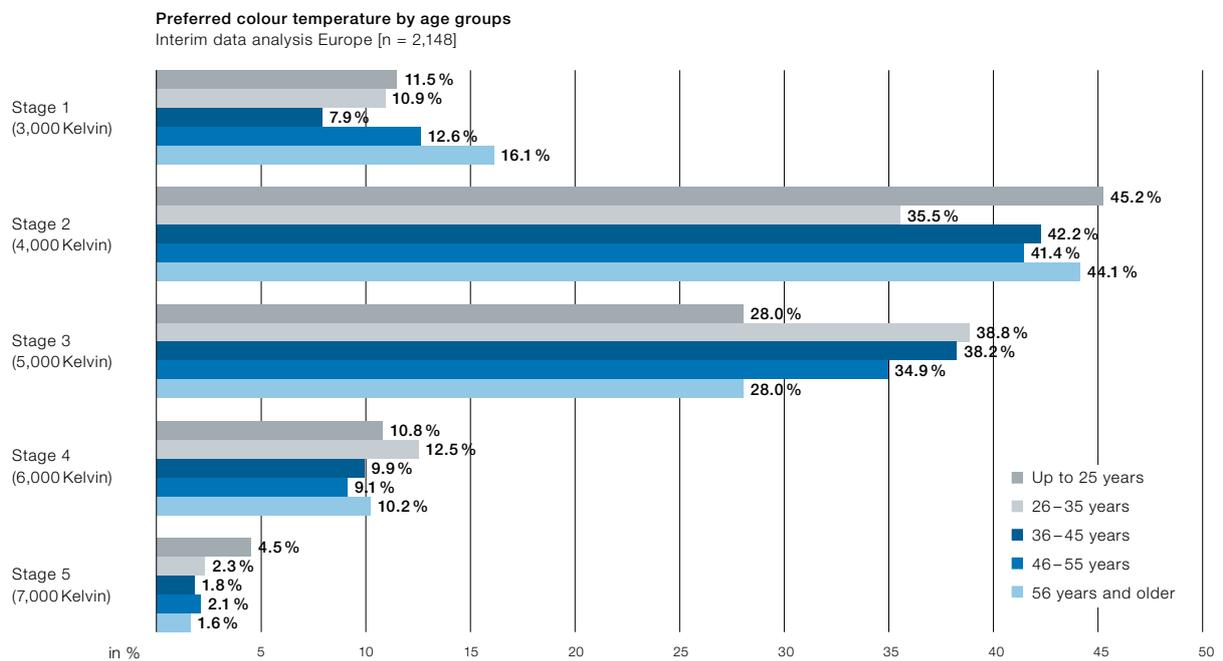


Figure 21:
The preferred colour temperature by age groups shows a heterogeneous distribution.

5 Results

5.4.2 Illuminance

More than 60 per cent of study participants prefer illuminance levels of 800 lux or higher. Almost 40 per cent are satisfied with 500 lux or less. The great majority accordingly wants illuminance levels marked higher than required by the relevant standards (Fig. 22).

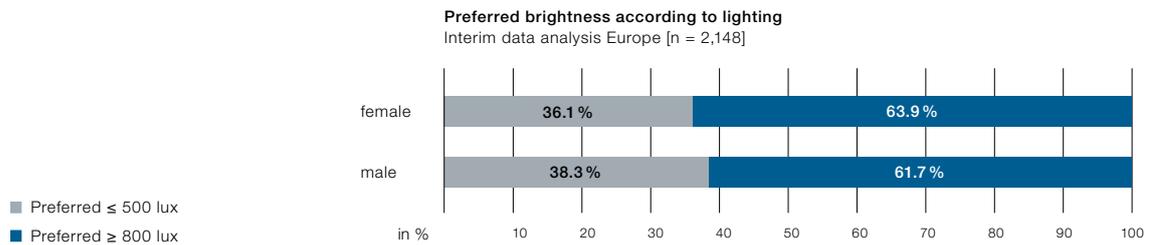


Figure 22:
More than 60 per cent of male and female participants prefer illuminance levels of 800 lux or higher at the workstation.

Whilst differences between the two sexes are minor, the desired illuminance levels show marked variations across the various age groups (Fig. 23): younger people up to the age of 35 turned out to be the “most hungry for light”. Almost 70 per cent of this age group prefer illuminance levels of 800 lux or higher.

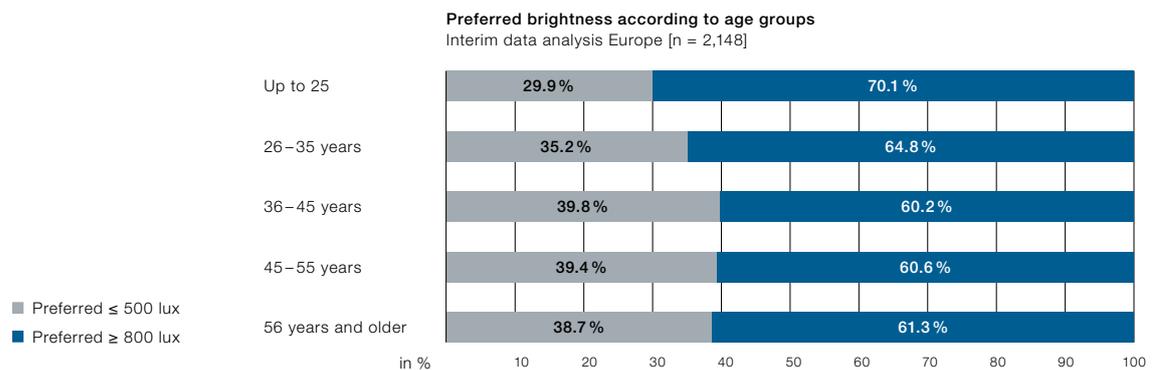


Figure 23:
Almost 70 per cent of the age group up to 35 years prefer illuminance levels of 800 lux and higher.

As opposed to that, the desire for high illuminance levels slightly decreases among survey participants older than 36 years, with 60 per cent still preferring 800 lux or higher. The result must be considered in the context that the seniors among the survey participants are more often seated in the immediate vicinity of windows.

The results show that only few of those surveyed actually have the ability to adjust the lighting in their office, to their individual visual needs (Fig. 24). 57 per cent of survey participants stated that currently they have only limited options, or none at all, to control the light levels above their workstation.

Distribution "I can always set or adjust the visual/lighting situation at my workstation to optimum effect."

Interim data analysis Europe [n = 2,148]

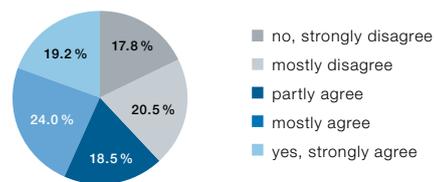


Figure 24:

Close on 57 per cent of all employees are not able to adjust their lighting to their individual needs, or at least only to a limited extent.

The study reveals an equally low degree of distribution in terms of light sensors for automatic control of office lighting: only 25.4 per cent of survey participants indicated that corresponding systems were installed at their offices (Fig. 25).

Distribution "Smart sensors help control the lighting at my workstation automatically."

Interim data analysis Europe [n = 2,148]

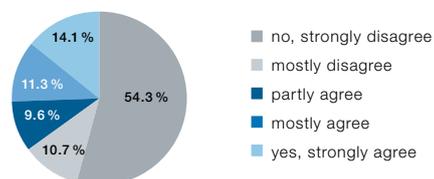


Figure 25:

65 per cent of participants indicate that no sensors are in place to facilitate control of their office lighting.

5 Results

5.4.3 Wellbeing

At a proportion of around 62 per cent, a majority of survey participants are working with either purely direct or purely indirect lighting. The group of study participants with direct/indirect lighting accounts for some 38 per cent. Contrary to that, the great majority of almost 82 per cent of survey participants prefer a combination of direct and indirect light (Fig. 26). The study shows that direct/indirect lighting has a positive impact on the wellbeing of users. It also illustrates, however, that less than half of office workers get the light that they desire to enhance their wellbeing.

Preferred type of lighting
Interim data analysis Europe [n = 2,148]

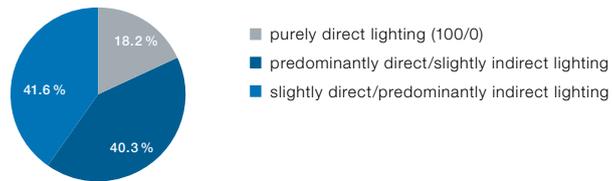


Figure 26:
Direct/indirect lighting is preferred by more than 80 per cent of survey participants.

Apart from light distribution, the possibility to individually control the luminaires is also an important factor for perceived lighting quality and wellbeing. The better the options to adjust the lighting, the more satisfied survey participants are with the lighting in their offices, and the higher they rate their visual/lighting layout (Fig. 27).

Wellbeing and satisfaction according to control options
Interim analysis Europe [n = 2,148]

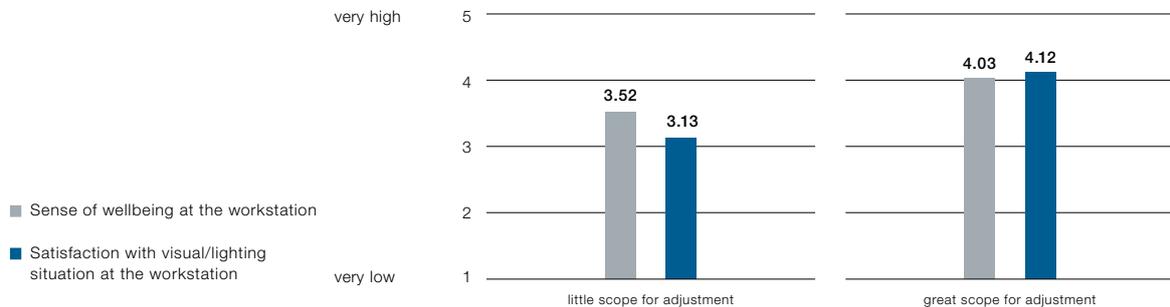


Figure 27:
Individually controllable lighting increases people's wellbeing and satisfaction with the visual/lighting situation.

What is remarkable in this context is that study participants give a significantly higher lighting quality rating where a free-standing luminaire is installed at their workstation (Fig. 28). As an autonomous source of light, individually controllable free-standing luminaires complement downlighting, thus allowing for an individual mix of direct and indirect light.

Assessment of wellbeing, satisfaction and lighting quality with or without free-standing luminaire.

Interim data analysis Europe [n = 2,148]

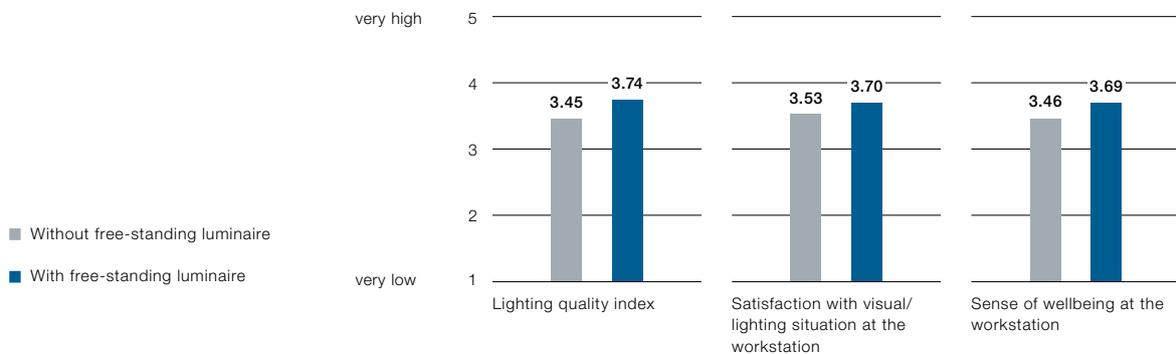


Figure 28: Where a free-standing luminaire is in place, both lighting quality and satisfaction in terms of the visual/lighting situation and wellbeing receive higher ratings.

To a large extent, the wellbeing of the survey participants also depends on the location of their workstation in the office, with immediate proximity to a window correlating with higher ratings. Generally, the wellbeing of study participants with a workstation in areas close to windows receives higher ratings (Fig. 29).

Assessment of lighting quality according to proximity to windows

Interim data analysis Europe [n = 2,148]

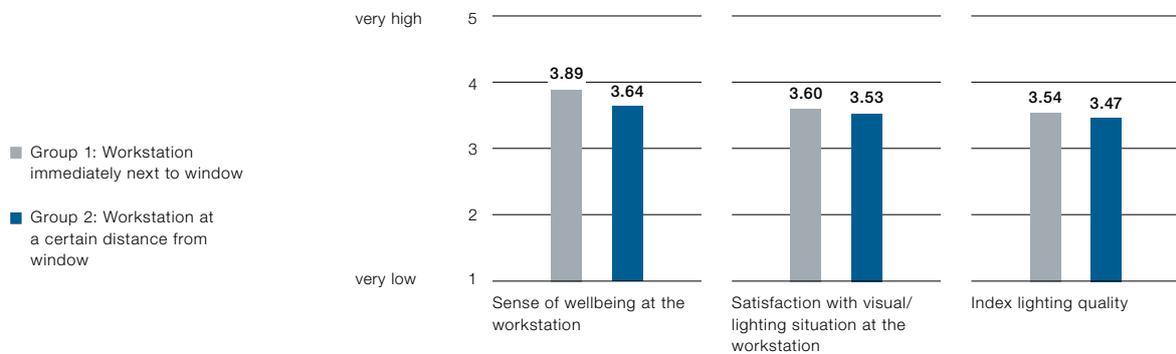


Figure 29: Workstations near the window contribute to people's wellbeing.

5 Results

Quite independently from the proximity to windows and the zone of occupation, satisfaction receives clearly more positive ratings for visual conditions and lighting layouts where LEDs are used as light sources (Fig. 30).

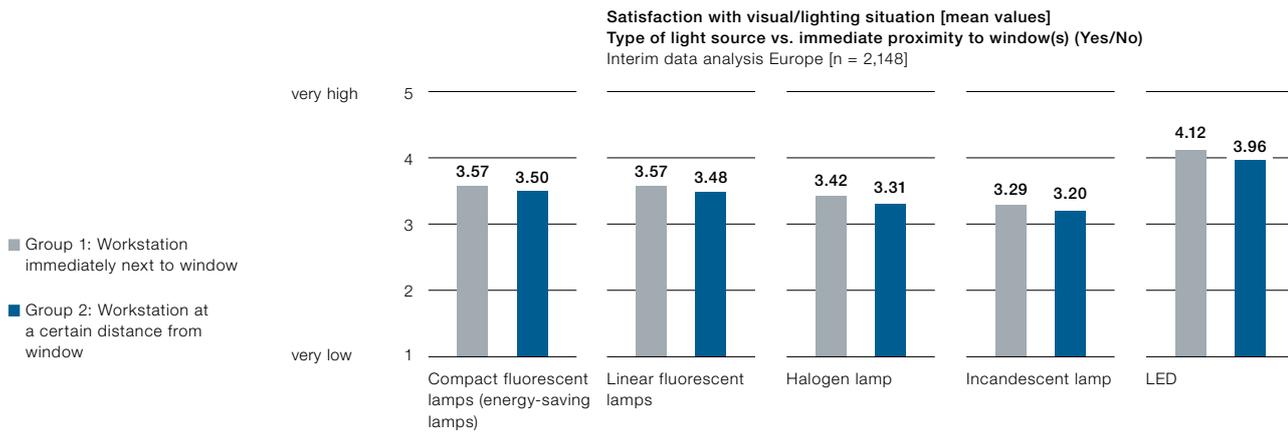


Figure 30:
 LED as the light source generally receives the highest ratings in terms of visual/lighting situation. In this context, it is insignificant whether the workstation is located in the first or second zone of occupation.

Wellbeing is highest among employees in cellular offices. Two-person offices also achieve comparatively high ratings (Fig. 31). People's wellbeing tends to decrease with the increasing number of persons per office – except if employees are able to shift flexibly between different workstations and office layouts. Similar correlations with the type of office can be seen with respect to the assessment of the lighting quality and in terms of satisfaction scores for the visual and lighting layout at the workstation (Fig. 32). The biggest challenges for lighting designers derive from open-plan environments and flexible office concepts including the option to change one's office workstation dependant on the task at hand.

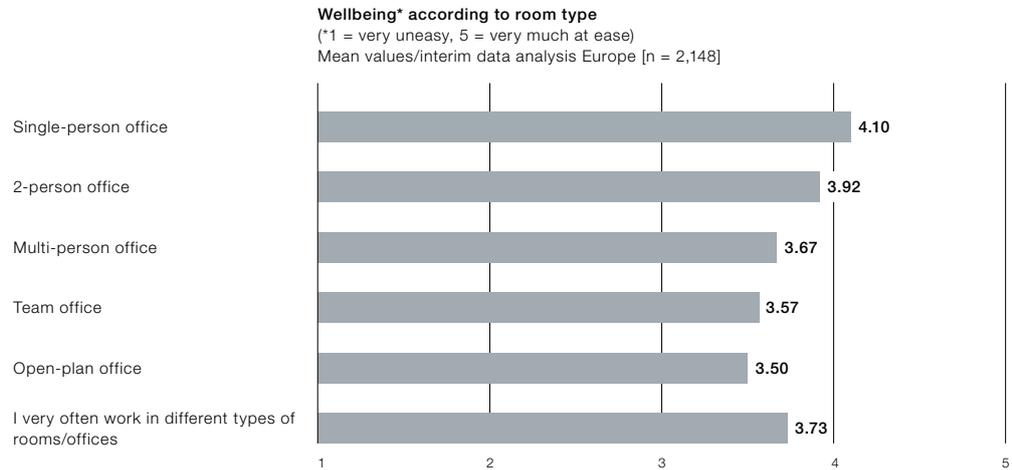


Figure 31:
 In smaller office layouts, ratings show enhanced wellbeing.

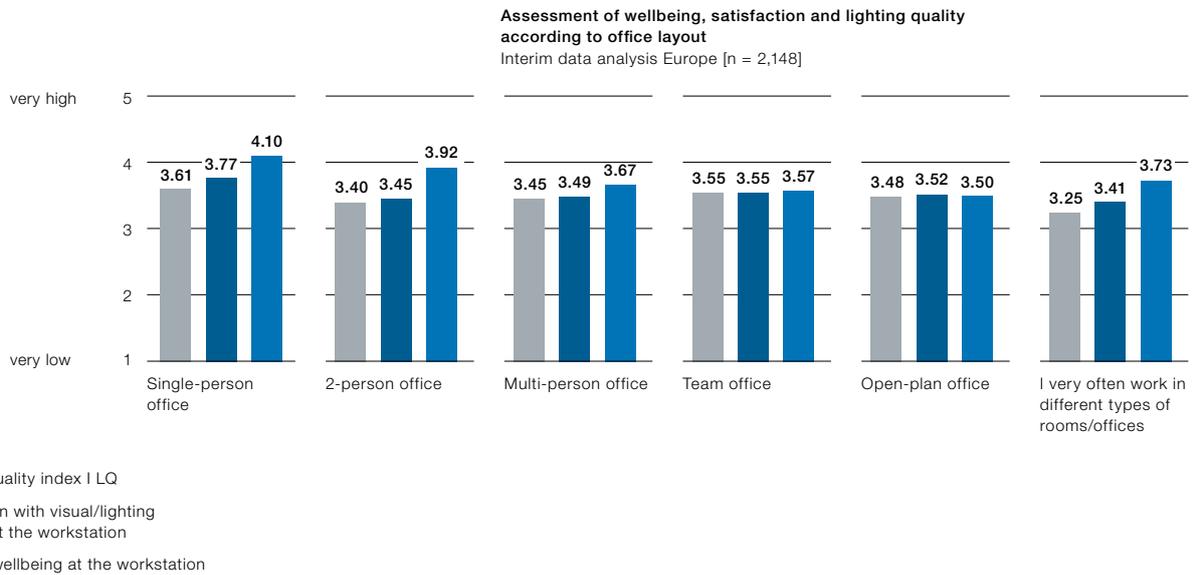


Figure 32:
 Smaller office layouts receive higher ratings in terms of wellbeing, satisfaction and lighting quality than open-plan offices.

6 Conclusion

The results of this study show the potential of user-oriented and application-based lighting in offices. Individually controllable light that focuses on the users, increases their wellbeing and promotes their health. It stimulates the human organism, increases cognitive performance and creates an emotional quality and atmosphere in the office. Owing to the availability of the latest adaptive LED lighting systems, lighting quality in the office is turned into a factor creating added value. According to a study that is now in the process of publication (Lighting Europe "Light and Health", A.T. Kearney), investing in user-centred, biologically effective lighting also provides economic benefits. Though productivity increases, improved wellbeing and reduces absence from work, very short ROI periods are achieved.

Therefore, the need for solutions oriented towards the individual needs of the users will continue to increase.

However, the required lighting, control and sensor technologies are not yet sufficiently used in practice.

The present study results allow for design principles to be derived as a basis for user- and task-adequate lighting concepts. For these principles to be applied in offices, next generation LED systems should be used that facilitate individual control, e.g. of brightness, colour temperature and light distribution dependant on the respective requirements, activities and room functions.

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