

STEFAN RIEF | MITJA JURECIC

AIR HUMIDITY IN THE OFFICE WORKPLACE

STUDY ON THE SIGNIFICANCE OF AIR HUMIDITY IN THE OFFICE



FRAUNHOFER INSTITUTE FOR INDUSTRIAL ENGINEERING IAO

Stefan Rief, Mitja Jurecic

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1 Initial situation

Besides air quality, room acoustics and lighting, the room climate is a work environment factor that influences a person's well-being, performance and health. The room climate is significantly determined by the relative air humidity and the room temperature.¹ In recent years, air humidity, in particular, has rarely been examined comprehensively in practical situations, even though office utilisation, building technology, humidification options and the demands placed on office space have changed drastically over the years.

This survey shows the significance of air humidity in the office and the effects it has on a person's well-being, performance and health from a user's perspective.

It focusses on the following key issues:

- Perception and assessment of the work environment with and without technical air humidification,
- Noticeable symptoms depending on the air humidity in the office.

The existing results are mainly based on the following sources:

- Delphi study »Working Environments 4.0 – How we will live and work tomorrow« (2012),
- Explorative survey »Air humidity at the workplace« (2013),
- »Office Settings« study (2014),
- Internet-based survey »Air humidity at the workplace« (2014).

1.1 Room climate and comfort

The relative air humidity and the room temperature are two of the basic conditions for a comfortable room climate. Ideally, the air humidity should be between 40 and 60 percent at a room temperature of between 19 and 22° Celsius. Furthermore, high-quality, pollutant-free room air and a sufficient supply of fresh air contribute towards a comfortable room climate.²

¹ See (Bauer et al.; 2007)

² See (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; 2009)

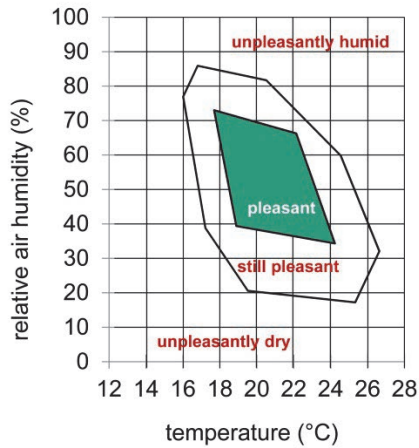


Figure 1: Comfort zone (IBO 2009)

Everyone has a different perception of comfort. It depends on the level of activity, physical factors, such as age, stress perception, vitality, as well as clothing and the duration of stay in the room.³

1.2 Delphi study »Working Environments 4.0«

The starting point of the surveys is the Office 21 Delphi study »Arbeitswelten 4.0 – wie wir morgen Arbeiten und Leben« (Working Environments 4.0 – How we will work and live tomorrow). In a forecast of the year 2025, more than 100 experts in the fields of economics, science and politics were questioned on how they believe the office environment will change over the coming years. Forty-eight key theses had to be evaluated. The importance of room climate and air humidity will increase in future; this was proven by a survey of expert opinion on the following theses:

Thesis 22: »Offices have developed into highly specialised places of maximum productivity and diversity. The unlimited promotion of the performance and well-being of office and knowledge workers (for instance interference-free acoustics, optimum lighting, optimum air humidity, attractive ambience) therefore dominates all other aspects of the office design and has upstaged topics such as space efficiency, IT investments and operating costs«.

³ See (Bux; 2006)

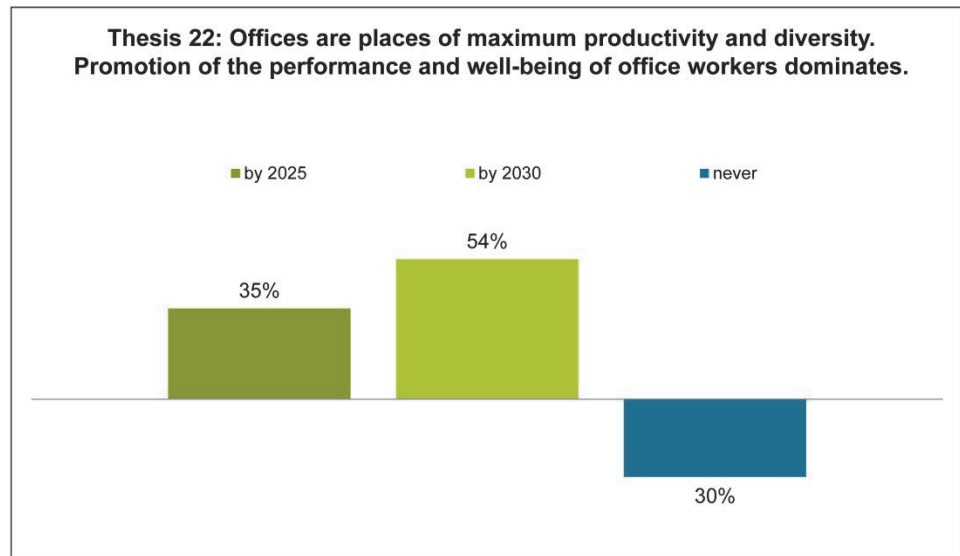


Figure 2: Thesis 22 from the study » Working Environments 4.0« (Fraunhofer IAO)

Roughly 35 percent of the surveyed experts expect that this central idea of office design will have asserted itself by 2025 and more than half of the respondents believe this might happen before 2030. Thirty percent think that the developments stated in the thesis will not take place.

Thesis 32: »Knowledge of the influence of the room climate on the health and performance of office workers has in the meantime been accepted insofar as an optimum room climate (temperature, air humidity, ventilation) prevails in almost every office all year round«.

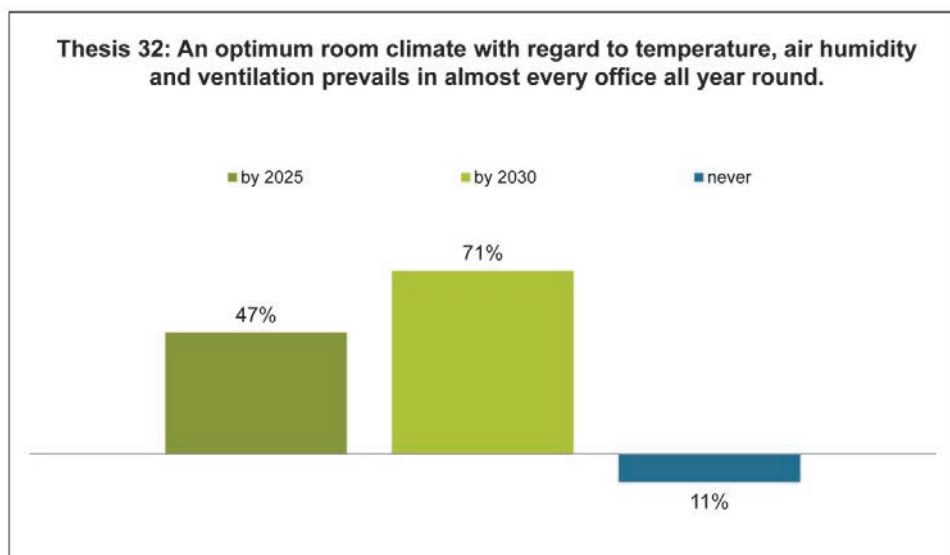


Figure 3: Thesis 32 from the study »Working environments 4.0« (Fraunhofer IAO)

Seventy-one percent of the experts think that this thesis will be reality by 2030 at the latest. Forty-seven percent believe that this thesis will come true before 2025. And just one tenth of the respondents cannot see this development taking place.

1.3 »Office Settings« study

The Office 21 »Office Settings« study examines, amongst other, the effect various work environments have on the performance, motivation and well-being of office and knowledge workers. More than 1100 people have already taken part in this Internet-based survey as the basis for data analysis.

Dry air can be an interference factor in office environments. This is shown by the answer to the question of whether indoor air is very often perceived as too dry. Roughly half the respondents feel that the air humidity is not or definitely not too dry, 21 percent were undecided on this point. With 8 percent and 18 percent agreement, more than a quarter of the respondents think that the air is often or very often too dry.

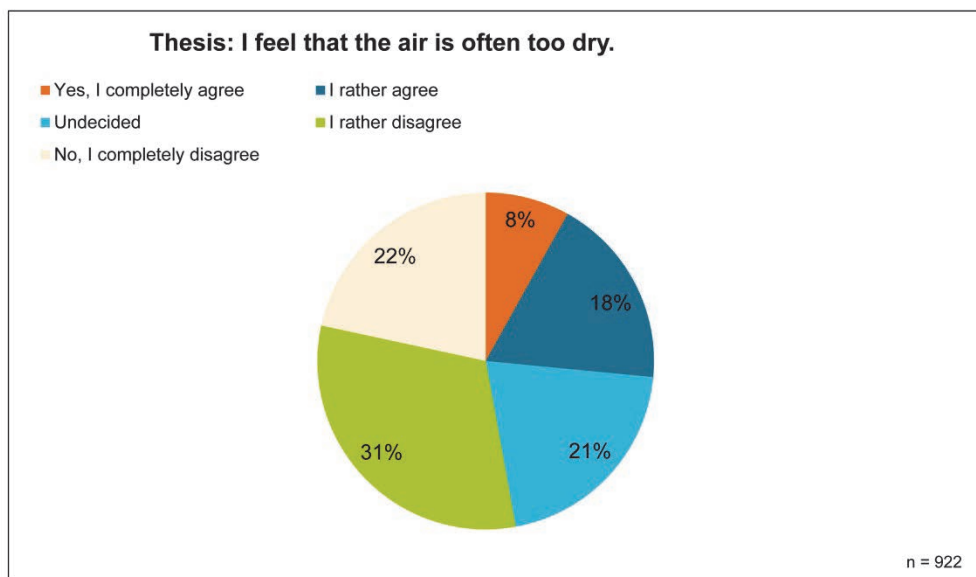


Figure 4: Dry air

This feeling is reflected in the level of satisfaction with the office environment: With a correlation of -0.30^{***} , dry air in the office environment clearly has a negative effect on the level of satisfaction. Statistically, the result is highly significant; a probability of error is thus excluded (< one percent).

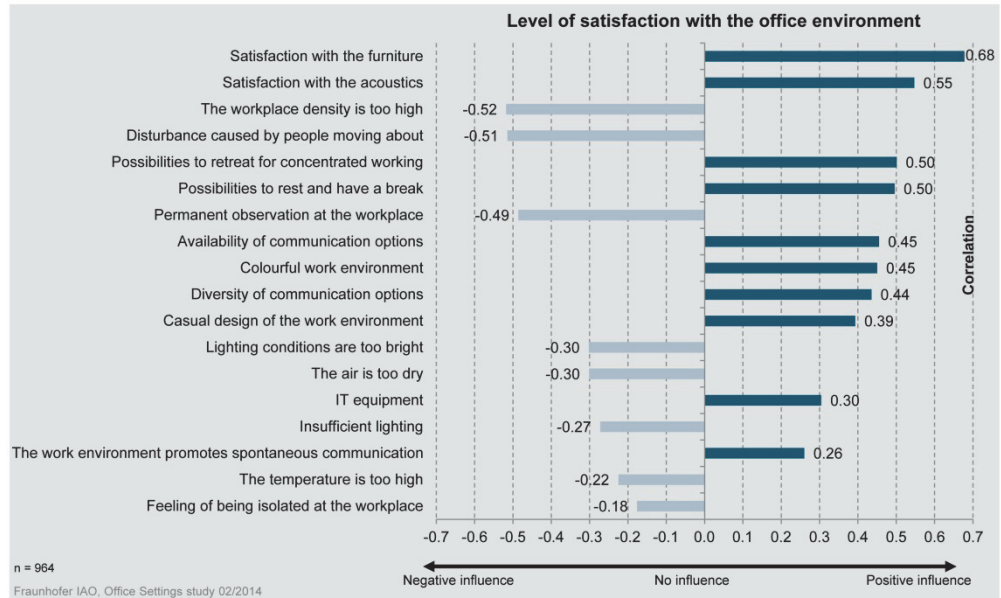


Figure 5: Influential factors on the level of satisfaction with the office environment, »Office Settings«-study (Fraunhofer IAO, 2014)

The level of satisfaction with the office environment is a key factor of success. Basically, it can be assumed that the level of air humidity in the office environment affects personal performance.



Figure 6: Level of satisfaction with the office environment, »Office Settings«-study (Fraunhofer IAO, 2014)

Based on this initial situation, the details of the effect of dry air and possible symptoms will be described in more detail below from a user's perspective. It is based on the results obtained through a periodical, exploratory survey and an additional internet-based survey.

2 Evaluation of an exploratory survey in the Workspace Innovation Lab



Figure 7: Workspace Innovation Lab at Fraunhofer IAO

2.1 Set-up of the survey

Between December 2012 and May 2013, employees were periodically surveyed at the Centre for Virtual Engineering of the Fraunhofer Institute for Industrial Engineering IAO. The surveys focussed on the Workspace Innovation Lab, which carries out research on how different ambient situations and working methods influence the performance, motivation and well-being of office and knowledge workers.

Three direct room air humidifying systems (DRAABE NanoFog Evolution) were used in a confined office space. This area, with a constant relative air humidity of between 39 and 42 percent, is the reference area for the survey which was carried out over a total of four survey periods. Within these periods, the direct room air humidification was switched on or off in the surveyed room for several weeks. The survey results for air humidification »on« and air humidification »off« were compared to other areas in the building without visible air humidification. The remaining areas feature neither a visible nor an invisible air humidifying system.

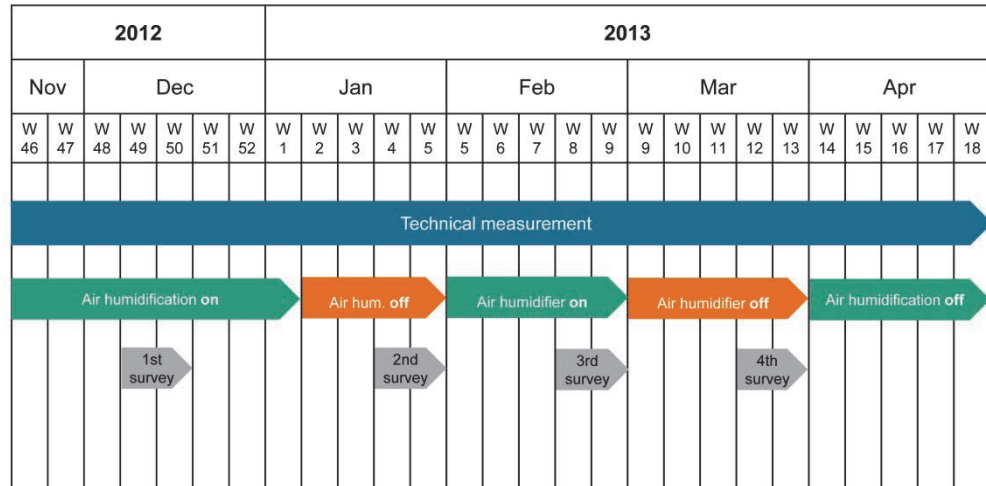


Figure 8: Survey periods 2012-2013

2.2 Results of the exploratory survey

The survey of room users was aimed at describing the work environment and assessing the air humidifiers. A total of 64 people participated in the survey. Users were able to partake more than once by completing an online questionnaire. Most of the respondents were relatively young. Forty percent of the participants were younger than 30, 45 percent were between 31 and 45.

Due to the relatively low sample, especially for assessing the office space with installed air humidification, the survey in the Workspace Innovation Lab is classed as an exploratory survey. The results are initially suitable for illustrating indications of the effects which need to be quantified more precisely in a further step (refer to Chapter 3 Internet-based survey). As the relevant measured values »relative air humidity« and »temperature« are fully recorded and documented in the Workspace Innovation Lab, the results may present a transparent picture of the climate situation in the respective scenario.

A five-point scale, ranging from »complete agreement« to »complete disagreement«, is used by the users to assess the work environment and the air humidifiers. The levels of agreement »I fully agree« and »I rather agree« are summarised for the following explanation of the results.

2.3 Low air humidity

When questioned about how the air humidity is perceived, a difference becomes apparent for the various scenarios: With active air humidification, none of the respondents agree with the statement that the air humidity is often felt as being too low. However, if the air humidifiers are inactive or for all surveyed areas without air humidifiers, 44 percent agree with the statement. The difference of the relative air humidity to the constantly humidified reference area is roughly 16 percent.

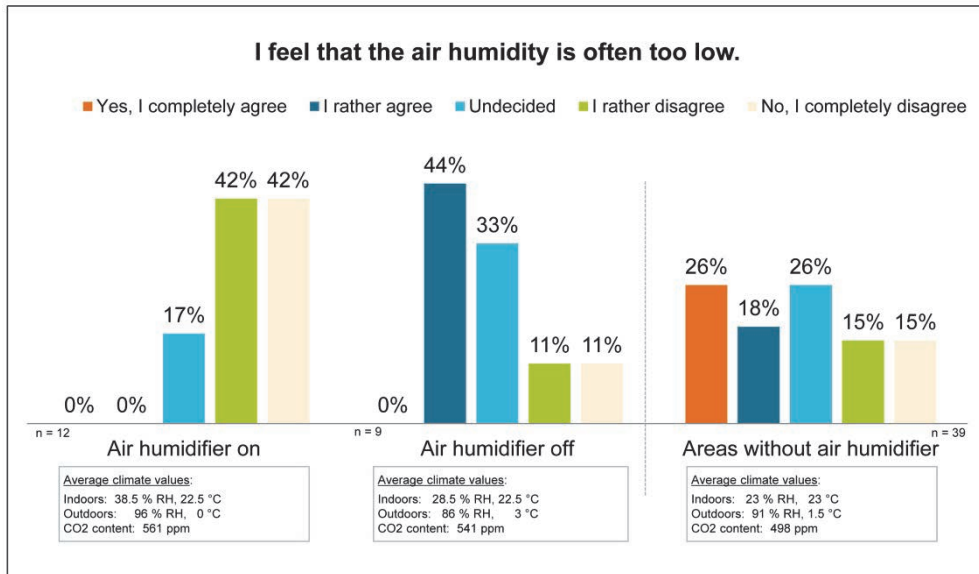


Figure 9: Air humidity is too low

2.4 Refreshing room climate

When creating additional air humidity via direct air humidifying systems, very fine aerosols (micro liquid droplets) that are visible and can be felt in the immediate vicinity of the humidifiers enter the air. This type of air humidification and the resulting average increase in relative air humidity from 28.5 to 38.5 percent result in a positive feeling for office users: Fifty-four percent of the respondents consider the direct room air humidifiers to be very refreshing. Conversely, there is only 33 percent agreement when the direct air room humidification is inactive.

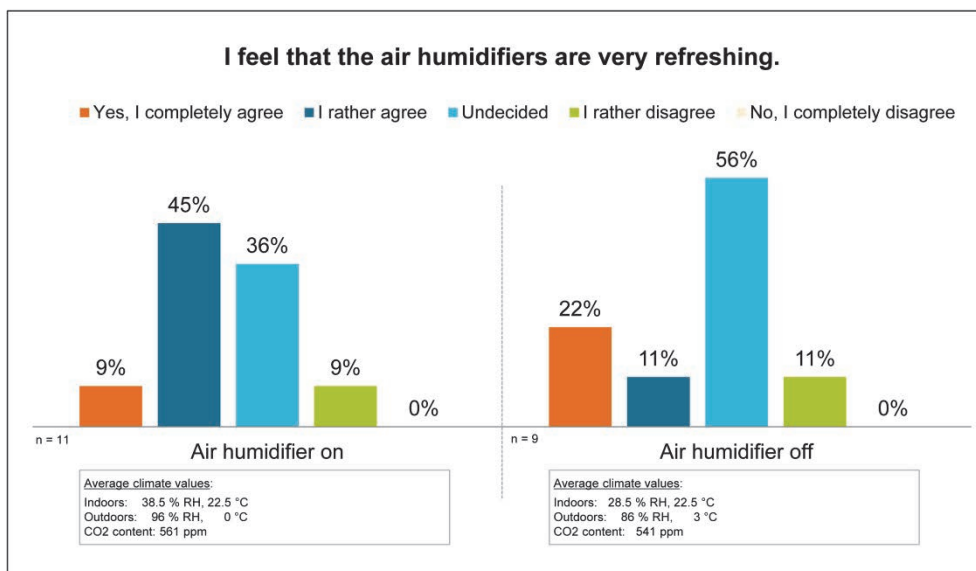


Figure 10: Refreshing room climate

The fact that the differences in the assessment are not greater and the highest agreement level of 22 percent in the deactivated status is more than twice as high as for active air humidification might be linked to a psychological effect: Due to the visibility of the air humidifiers in the room, it is conceivable that some users feel the climate is enhanced – irrespective of whether the humidifiers are active or inactive.

The noticeable freshness cannot be traced back to a reduced room temperature. In both surveyed scenarios, the average room temperature was 22.5° Celsius during the considered 27-week period. The freshness effect can only be explained by the generated air humidity supported by the psychological effect of visible air humidification.

2.5 Air humidifiers are not considered annoying or irritating

A conflicting effect that users are easily distracted and disturbed from their work by the visible, audible and palpable direct room air humidification is not apparent. Most respondents do not consider the air humidifiers to be annoying or irritating. The differences between the scenarios with and without active air humidification are only marginal: If the air humidification is inactive, 88 percent of the users feel undisturbed; if the air humidifiers are active, 83 percent of the users feel undisturbed. Acceptance problems due to the technical properties of the surveyed direct room air humidification are thus not be expected.

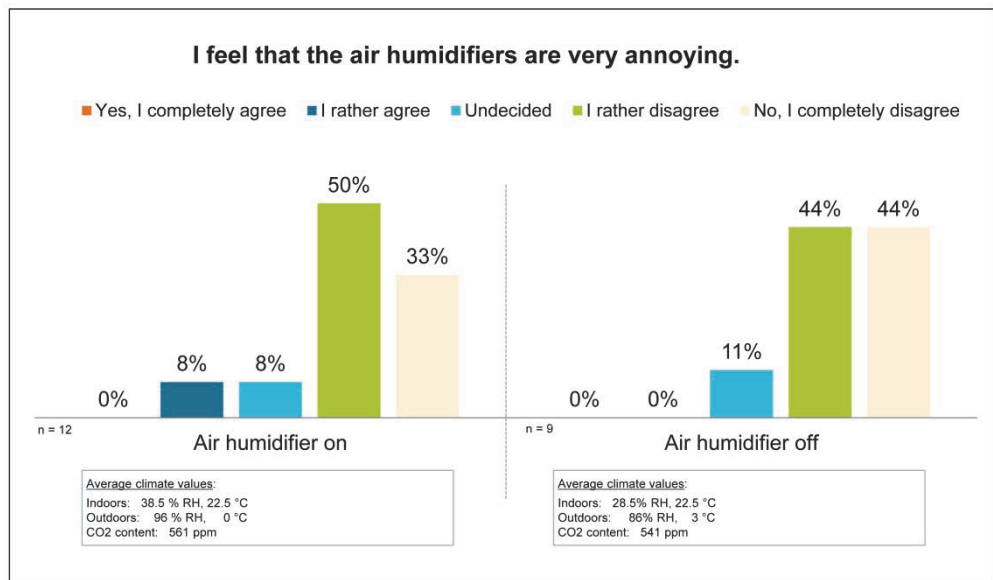


Figure 11: Disturbance caused by air humidifiers

3 Evaluation of an internet-based survey on air humidity in the workplace

3.1 Set-up of the survey

The online-survey addressed users of direct room air humidification and companies with a potential interest in air humidification. The survey was carried out in the spring of 2014. The pre-selection of eligible companies took place via an ex-ante evaluation by phone. Contacts were company representatives at decision-maker level who are actually involved in the process of enhancing the workplace. A total of 167 people took part in the survey. As only complete answers were considered, 101 participants were included in the final evaluation.

The survey was aimed at seeking a general description of the work environment and possible symptoms of dry room air. Due to the extended sample, the survey is classed as a quantified follow-up survey of the exploratory study in the Workspace Innovation Lab (see Chapter 2 »Evaluation of the survey«).

3.2 Results of the online survey

Forty percent of the answers refer to the companies which currently use direct air room humidification for their offices or in other business areas. The companies that see a need for additional air humidification but have yet to make a decision in favour of retrofitting direct room humidification are represented by 60 percent of the participants.

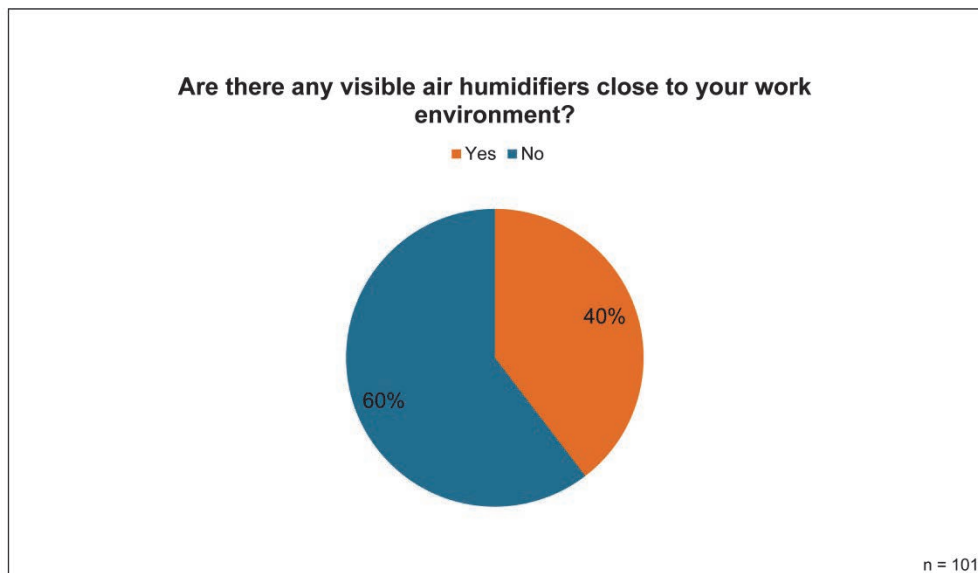


Figure 12: Frequency of air humidifiers

Fifty-eight and 42 percent of the participants are female and male respectively. The age of most of the respondents is between 31 and 44. Considerably less participants are under 31 or over 55, with each age group represented by 10 percent of the respondents. The age and gender profile of the respondents complies with expectations.

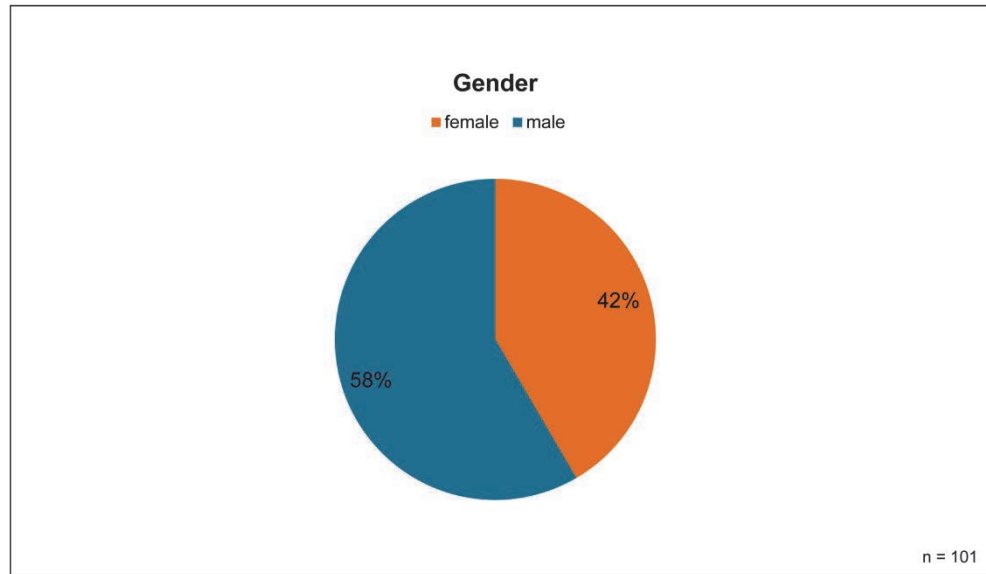


Figure 13: Gender profile

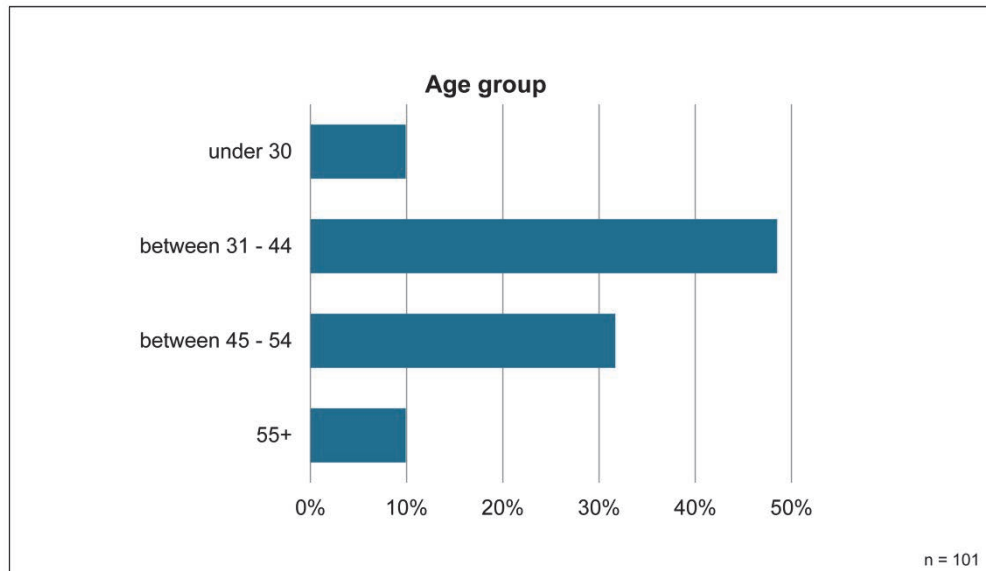


Figure 14: Age profile

A three-point scale, ranging from »agreement« through »undecided« to »disagreement«, is used by users to assess the work environment and the symptoms. The answers of the groups »with visible room humidification« and »without visible room humidification« are compared.

3.3 Difference based on gender and age

As to be expected, the perception of air humidity in offices with and without air humidification differs: Half of the participants from offices without air humidification often feel that the air humidity is too low. On the other hand, less than a third of the people working in offices with air humidification feel the same. However, at 30 percent, the level of agreement in this group can be evaluated as proportionally high. As it was not possible to query measured values via the online survey, it is impossible to

answer how high the actual relative air humidity is and whether optimum values of about 40 percent relative humidity are achieved.

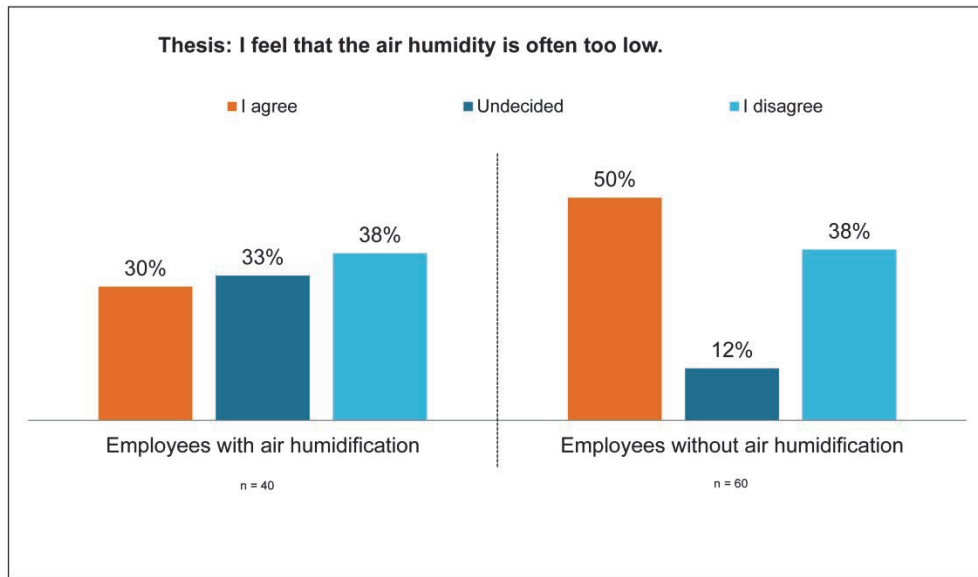


Figure 15: Employees with air humidifiers vs. employees without air humidifiers

It is interesting to take a look at the demographic data of the participants: Gender as well as age have a definite effect on the perception of air humidity. Women are more sensitive to air humidity and feel more disturbed by lower values. In the group of participants without air humidification, the ratio between women and men who often feel that the air humidity is too low is 60:40.

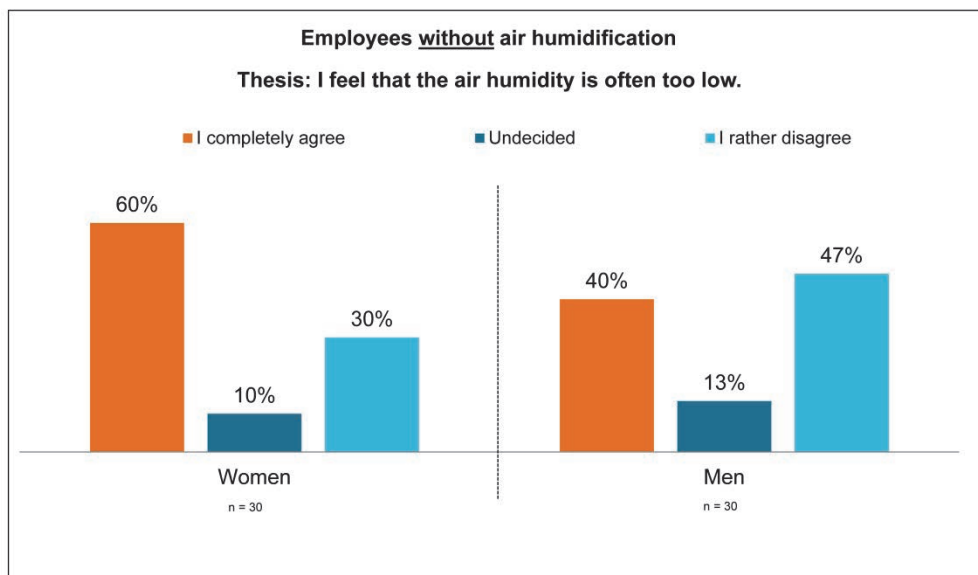


Figure 16: Differences between the genders

In the age groups, it is particularly the middle-aged participants between 31 and 54 who feel that low air humidity is unpleasant. In the group between the ages of 45 and 54, the percentage even rises to 61 and is thus three times more than in the under 30 group. Possible reasons for this might be the diminishing viscosity of the mucous mem-

branes of the respiratory tract with increasing age or the higher work loads placed on middle-aged employees reflected in a more acute perception of the work environment.

3.4 The »dry eye«

Besides the general perception of the air humidity at the workplace, the recording of possible symptoms which affect the health of office workers is another key aspect of the survey. Publications describe the possible effects, especially on the mucous membranes of the respiratory tract, vocal tract and the eyes.

As office work nowadays also always includes working in front of a monitor, the possible load on the eyes is considered as an important parameter for the general ability to concentrate and perform. One of the questions of the survey therefore focusses on a well-known symptom which correlates to the symptoms of the so-called »dry eye« syndrome defined by eye specialists. The tear film protects the eye surface against inflammation and infection of the conjunctiva. The dimension of the tear film also depends on the air humidity. Sustained dry room air results in increased tear fluid evaporation. Fine air particles and dust can thus enter the conjunctiva through cracks in the tear film. Increased blink frequency, unpleasant »grittiness«, increased sensitivity to glare and burning eyes may be an indicator of eye inflammation.⁴

Answers about the »burning eye« symptom show significant differences between office spaces with and without air humidification: Forty-one percent of the respondents in offices without air humidification confirmed that they often feel a burning sensation in their eyes when working. If air humidification is used, the discomfort is reduced by nearly half. Only 23 percent of the surveyed office workers then suffer from burning eyes.

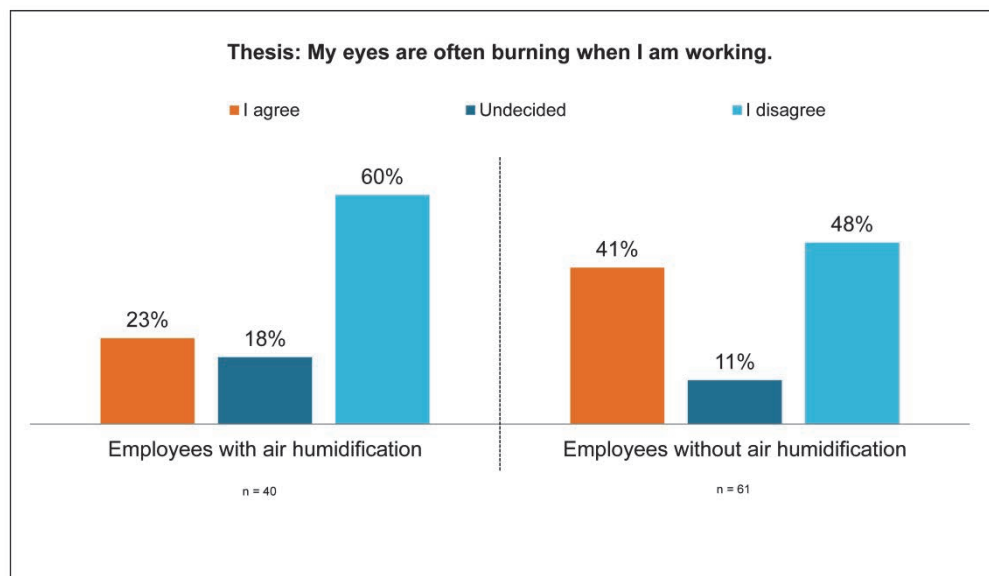


Figure 17: Eye disorders

⁴ See (Berufsverband der Augenärzte Deutschlands e.V.; 2007)

The survey results show that the application of an air humidifying system can reduce the discomfort caused by eye irritations. Furthermore, the general lighting conditions in an office, e.g. glare, and the ergonomic design of monitors must also be considered.

3.5 Dry mucous membranes

The mucous membranes of the respiratory tract (nose, bronchi, lungs) fulfil an important protective and self-cleaning function. The viscosity of the mucous membranes is decisive for how quickly viruses can be cleared from the body. The faster it occurs, the lower the risk of illness. Clinical surveys support the view that air humidity can influence the viscosity of the mucous membranes.⁵ The more viscous the mucous layer, the less effective the self-cleaning. Survey show that a fast, efficient cleaning function of the respiratory tract requires a sufficiently high level of air humidity of at least 30 percent. The quickest transport speed is achieved at a relative air humidity of 45 percent. The self-cleaning function is blocked completely when humidity is below 20 percent.⁶

Against this background, the question aims to determine to which extent a dry respiratory tract is perceived by the respondents.

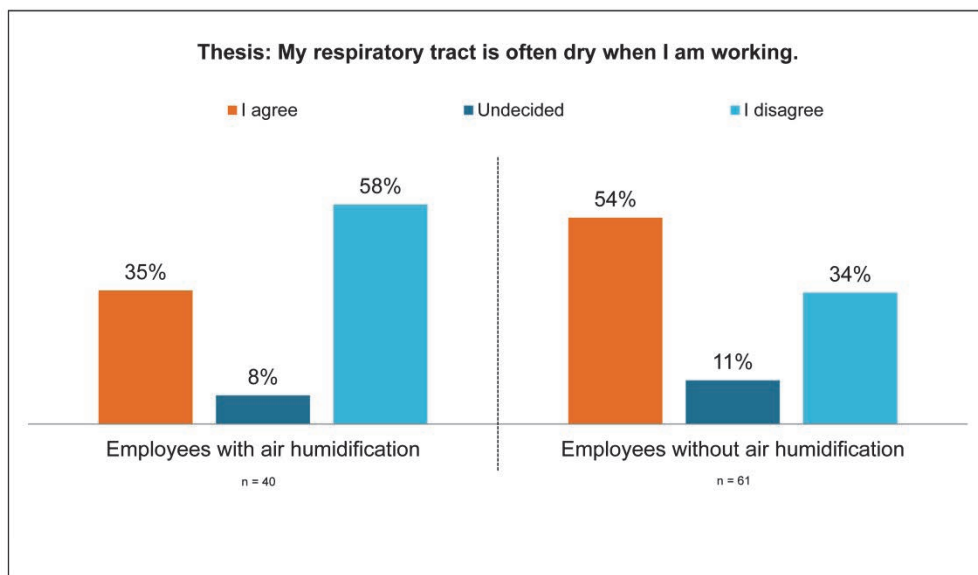


Figure 18: Problems with the respiratory tract

Similar to the question about burning eyes, different agreement levels appear in the surveyed groups: Fifty-four percent of workers in offices without air humidification agree with the statement that they often have a dry respiratory tract at work. In workplaces with air humidification, the discomfort caused by a dry respiratory tract is reduced by more than a third to 35 percent.

⁵ See (Guggenbichler; 2007)

⁶ See *ibid.*

3.6 Vocal problems

Primarily, occupational groups that have to talk a lot are at high risk of suffering vocal disorders as a result of permanently using their voice. More than 60 percent of call centre staff regularly suffer problems brought on by the excessive use of their voice.⁷ Frequent symptoms are dryness in the throat and larynx, an urge to swallow, increased throat-clearing and hoarseness. The voice is produced in the larynx where the vocal folds and vocal cords surrounded by mucosa are situated. It has been proven that this sensible mucosa requires constant humidity to ensure healthy functioning of the voice and effortlessly production of sound. Generally, a minimum air humidity of 40 percent is recommended for occupational groups whose work involves a high level of talking.⁸

The survey shows a tendency for vocal problems to increase with low air humidity: In work environments without air humidification, roughly one third (29 percent) of the people working there often suffer from problems with their voice. If the air is, however, continuously humidified, only 18 percent of the respondents complain about frequent vocal problems. The difference is even higher with the respondents who answered that they rarely suffer from problems with their voice: Without air humidification, roughly half (47 percent) scarcely encounter problems. With air humidification, almost two thirds (65 percent) of those interviewed said vocal problems are not a common reason for complaint.

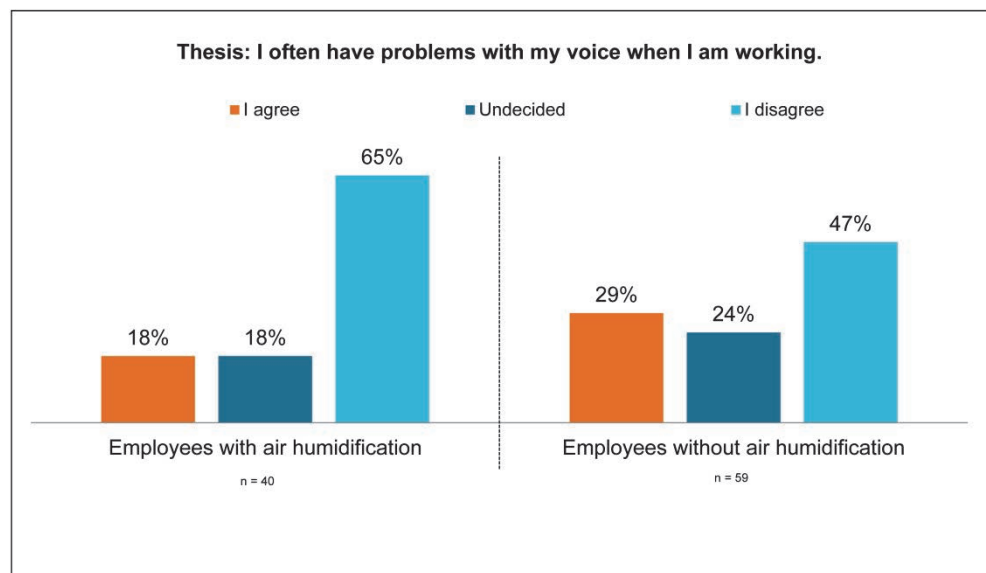


Figure 19: Vocal problems

Additional air humidification is thus confirmed as a preventive measure to reduce vocal problems in the office environment. Besides air humidity, background noises in the office, poor room acoustics and inadequate voice projection have, for instance, an influence on the development of vocal problems.

⁷ See (Verwaltungs-Berufsgenossenschaft)

⁸ See (Deutsche Gesetzliche Unfallversicherung; 2005)

4 Summary

4.1 General significance of air humidity

Insufficient air humidity is a key interference factor in offices. More than a quarter of the surveyed office users often feel distressed by dry air in the workplace. Insufficient air humidity can impair the level of satisfaction with the office environment and have a negative impact on a person's well-being, motivation and performance.

Results of the Delphi study »Working Environments 4.0« predict that the issue of air humidity in the office and work environment will become increasingly important in the future – realistically within the next 15 years. The knowledge of the impact of the room climate on the health and performance of office workers is widely accepted. An optimum room climate with sufficient air humidity will then prevail in almost every office all year round.

4.2 Perception in the work environment

The generation of additional air humidity tends to be assessed as refreshing. To this end, it must, however, be considered that the air humidity is at least 40 percent and the temperature is within the normal range of between 19 and 22° Celsius. Application of direct room air humidifying systems is not considered to be annoying or irritating in the office and is thus accepted. Both gender and age have an effect on the perception of air humidity.

4.3 Influence on a person's well-being and health

The survey shows that the participants in office areas with and without air humidification suffer differently under the described symptoms caused by dry air. This confirms an influence of air humidity on possible eye irritations, dryness of the mucous membranes and possible vocal problems. The respondents in offices with additional room air humidification express less discomfort regarding the examined symptoms. Air humidity at the workplace can thus be assessed as a building block for increasing a person's well-being and for possibly reducing health risks. As today's working profile in the office also almost always includes working in front of a monitor and using one's voice, a positive influence can be deduced from the reduced level of stress on the eyes and voice.

However, it must be noted for all examined symptoms that air humidity is only one possible parameter. Other parameters of the work environment and personal factors also play a vital role. A mono-causal deduction of cause and effect is therefore not viable. It has, however, been confirmed that the additional application of air humidifying systems has a positive effect on the assessment of the workplace and can also influence the performance and health of office workers.

5 Joint research project Office 21®

Fraunhofer Institute for Industrial Engineering IAO deals with current issues concerning the working population.

The introduction of new work and office environments has far-reaching consequences for companies and is increasingly becoming a crucial factor of success. The organisational, technological and interior design of the work environment can have a significant impact on the well-being, motivation and performance of staff. In the joint research project Office 21®, Fraunhofer IAO examines the question of how work and office environments are going to change in the future and develops concrete courses of action for the successful design, planning and implementation of these environments. Together with a multidisciplinary network of scientists, innovative solution providers and visionary users, Office 21® wishes to identify future developments at an early stage and to develop precise courses for action for the successful design of new work environments in companies.

For further information, please visit:

www.iao.fraunhofer.de

www.office21.de

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6 List of references

Bauer, M.; Mösle, P; Schwarz, M.: Green Building – Konzepte für nachhaltige Architektur. Munich 2007.

Berufsverband der Augenärzte Deutschlands e.V. (Ed.): Das Trockene Auge – eine ernstzunehmende Krankheit. Düsseldorf 2007.

Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft in Kooperation mit dem IBO – Österreichisches Institut für Baubiologie und -ökologie (Ed.): Wegweiser für eine gesunde Raumluft [<http://www.raumluft.org/fileadmin/dokumente/wegweiser.pdf>, updated 20.08.2014].

Bux, K. Climate at the workplace. The state of codes of practice - Need analysis for further research. Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dortmund 2006

Deutsche Gesetzliche Unfallversicherung (Ed.): Report der gewerblichen Berufsgenossenschaften: Innenraumarbeitsplätze – Vorgehensempfehlung für die Ermittlungen zum Arbeitsumfeld. Berlin 2005.

Guggenbichler, P.: Heizung Lüftung Klimatechnik: Luftfeuchtigkeit und Immunabwehr. Vienna 2007.

Verwaltungs-Berufsgenossenschaft (Ed.): CCALL Special: Arbeiten in einem Sprechberuf [http://www.ccall.de/download_dat/headsets.pdf, updated 20.08.2014].

Imprint

Contact:

*Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO,
Nobelstraße 12, 70569 Stuttgart, Germany www.iao.fraunhofer.de*

Mitja Jurecic

Phone +49 711 970-5451

mitja.jurecic@iao.fraunhofer.de

Cover: © zmijak - Fotolia.com

Printing and Finishing: IRB

Mediendienstleistungen

Fraunhofer-Informationszentrum

Raum und Bau IRB, Stuttgart

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The study illustrates the significance of air humidity in the office and the impacts it has on well-being, performance and health from the user's perspective.

The survey focuses on the following topics:

- Perception and evaluation of the work environment with and without technical air humidification
- Sensed symptoms dependent on the air humidity in the office

The study has been conducted as part of the conjoint research project

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Zukunft der Arbeit