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Personal environmental control: Effects of pre-set conditions for heating and lighting on personal settings, task performance and comfort experience

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ABSTRACT

The effects of pre-set environmental conditions of temperature and lighting on the preferred personal settings, comfort experience and task performance of office workers were investigated in an individually controlled workstation. Twenty subjects performed standardized tasks at a prototype workstation with individually controlled radiant heating and lighting in a climate room. In a repeated measures design, their adjustments to pre-set values were evaluated: low and high radiant heating power, low and high direct illuminance, low and high indirect illuminance. Results showed that preferred personal settings are dependent on the initial, pre-set values of radiant heating power and illuminance. Higher pre-set values result in higher adjusted operative temperatures and higher illuminances on desk, although the differences for heating were too small to show a convincing effect. After adjustment, visual comfort was higher, but it was not dependent of the pre-set values. For thermal comfort no differences were found. Individual task performance was not negatively affected. Providing personal environmental control and the way these concepts and interfaces are designed, play a significant role in user behavior and preferences. The design and control of individually controlled workstations as well as the interaction with the general level of the office environment should be carefully considered in order to obtain maximum comfort and energy efficiency.

1. Introduction

Increasingly, workplaces of knowledge workers [1–3] have to support rapid technology development and implementation, and must meet continuous changing work demands. Measures such as teleworking, open plan offices and working with shared workstations have been positioned as providing at least partial solutions to many of these challenges [4,5].

Ambient features of the office environment, like lighting, temperature, noise, presence of windows, have an important influence on attitude, behavior, health, satisfaction and performance of workers [4–13]. Although the importance of ambient features are commonly known, still many problems have been documented, such as noise, lack of privacy, thermal discomfort and concentration loss, especially in open offices [14,4,15]. Apart from the office chair, the desk and the computer settings which are adjustable on an individual level, the current workplace in an open office fits badly with the personal needs and preferences. So far, research has been guided by the search for a universally applicable set of optimum comfort conditions in the work environment [16]. In current work environments, these optimum comfort conditions regarding lighting, ventilation, decoration and climate are regulated on a general level in open offices or at room level. However, in order to achieve an optimal comfort experience, customized settings on a

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local, personal level are desired. Increasingly, concepts that offer personal comfort are being developed and evaluated (e.g. Refs. [17–21]). Already, an example of a local, individually controlled ventilation system based on research of Melikov [22] is on the market.

One of the concepts of 'Intelligent Building research', as formulated by Cole and Brown [16], is using information and communication technology to provide 'occupant intelligence', wherein a building explicitly enables its users to make appropriate adjustments in their local environmental conditions and at the same time providing and maintaining operational efficiencies in energy use. The essence of intelligent building concepts is that on all the settings of light, climate, sound and atmosphere, the greatest possible shift is pursued from averaged, spatial settings to individual, local settings [16].

The scientific literature gives evidence that providing personal control over the working environment (e.g. adjustment of lighting, temperature and air movement) may have beneficial effects on comfort, job satisfaction and productivity [4,6,14] [23–27], although no effects or negative effects are reported as well: e.g. Boyce et al. [28] found no effects and Veitch & Gifford [29] found that giving personal control over lighting conditions led to slower working and lower productivity. Therefore, when applying concepts with customized settings on a local, personal level in practice, it is important to evaluate task performance effects. Hedge et al. [6] distinguish between real personal control (the availability and the ease of use of the aspects that one can modify in the physical environment) and the experienced control (the experienced personal influence, the importance of the impact and consequences of the use of this influence). The interaction with the environment is an essential part and various factors such as behavior, attitude, design and ease of use play a role in the actual and proper use of individually controlled environments [6].

Research on the effects of providing personal control of environmental conditions is in an early stage. Although literature suggest that personal control of environmental conditions is beneficial for productivity, comfort and health, up to now these are not investigated in detail. There is little information on the triggers for exercising personal control over the environmental conditions and on the behavior of personal control over time when office workers are provided with the freedom to adjust their local environmental conditions [6,4].

Increased personal control over the environment conditions may be realized by providing just acceptable environmental conditions on general level combined with personal fine-tuning on local workstation level. In order to identify the potential of such a local individually controlled environment, in terms of user benefits as well as energy use, there is a need for clarity on aspects of human system interaction. To define design characteristics, important for application in practice, information is needed about the office workers' interaction with and response to the system (i.e. the values office workers choose), and how it affects their work performance and comfort experience.

The aim of the study was to evaluate the effect of pre-set environmental conditions of temperature and lighting on the preferred personal settings of office workers and the consequences of this on comfort and task performance. Literature shows that occupants have individual variations in desired sensation of thermal comfort (e.g. Refs. [30–35]) which assumes individual comfort margins instead of absolute comfort values. This has also been found for sitting comfort [36] and it might be applicable to visual comfort as well. This assumes that starting from high respectively low initial values, occupants will adjust their environmental conditions until reaching the top respectively the bottom of their individual comfortable range (Fig. 1). It was intended to find out whether the preferred, adjusted values of temperature and illumination depend on the initial, pre-set values of temperature and illumination at local workstation level and general room level. Moreover, it was investigated whether exercising personal control affects comfort and task performance of office work. For this purpose, a prototype of a workstation with individually controlled local radiant heating and lighting was used. The hypotheses were:

1. The preferred level of tuning is dependent on the initial, pre-set values of radiant heating power and illuminance.
2. The perceived level of comfort after adjustment is not dependent of the initial value of radiant heating power and illuminance.
3. Task performance is not dependent of the initial value of radiant heating power and illuminance.

2. Methods

2.1. Experimental design

In a within subjects (repeated measures) design, in which all of the subjects received all treatments and thus serving as their own 'control', six pre-set values were evaluated (low power of radiant heating, high power of radiant heating, low direct illuminance, high direct illuminance, low indirect illuminance, high indirect illuminance). The result of a within subject design is as many data sets as there are conditions for each subject. This is in contrast with a between subject design, where all subjects undergo one pre-set only. Although within subject design can lead to carry over effects, where subjects responses on later tests are influenced by their experience in earlier tests, this design was chosen to remove subject variation associated with individual differences and

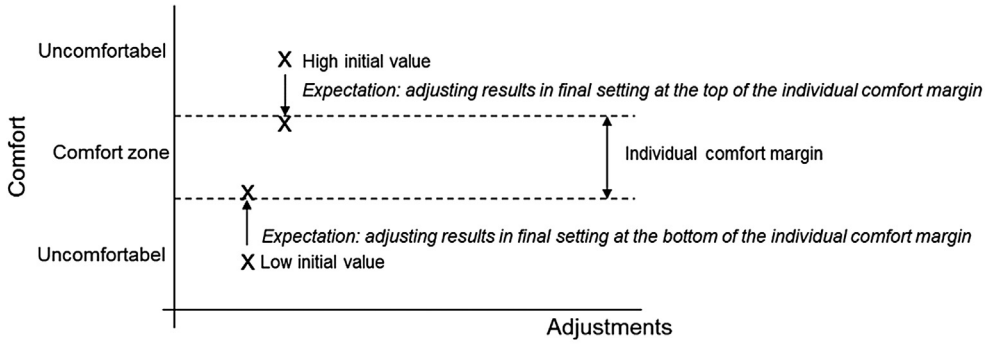

Fig. 1. Basic experimental principle: exercising personal environmental control until reaching the individual comfort margin and resulting final setting.