

AN HOLISTIC EVALUATION OF THE WORKPLACE ENVIRONMENT

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Research into the impact of the workplace environment has largely been focused upon the indoor climate i.e. illuminance, sounds, air movement, air temperature and relative humidity. This has led to the development of design guidance that outline the conditions necessary for a comfortable environment. Through analysis of 20 workplaces the impact of a whole range of factors comprising the workplace environment were evaluated. The findings demonstrate that the majority of people are satisfied with the indoor climate if all aspects fall within the recommended comfort ranges. On the other hand, people were less satisfied with aspects of the workplace related to spatial layout and the interior design of the workspace. Most significantly the majority of occupants were dissatisfied with the colour scheme, provision of plants, choice, personal control and break areas. It appears that the level of dissatisfaction is directly related to the level of research conducted into a specific factor. The results of this first phase of research have informed a pioneering study of stimulation in the workplace. Experiments within a workplace are being conducted to determine whether occupants' levels of stimulation in the afternoon, when attention levels typically fall, can be maintained at an optimal level through the manipulation of the environment. The implications of these studies upon workplace design and future research are discussed.

Keywords: environment, productivity, satisfaction, stimulation, workplace.

INTRODUCTION

Currently full time employees spend on average 42 hours per week at work and over 50% of the working population in the United Kingdom work in an office environment (Office of National Statistics, 2005). However, little conclusive evidence exists to explain what impact the workplace environment has upon people. There is some limited evidence from studies of individual aspects of the workplace to suggest a relationship between the environment and occupants' satisfaction and perceptions of productivity; but the majority of research to date has been the analysis of variables that are easy to measure quantitatively, namely the physical environment and spatial layout. The more qualitative variables that are more difficult to measure have been identified by researchers but rarely analysed (Bordass & Leaman, 2001). However, researchers have often discussed the complexity of the workplace environment and suggested that qualitative variables should not be ignored (Crouch & Nimran, 1989).

A significant influence on workplace design has been evolving management theory. The development of Scientific Management Theory by Frederick Taylor (Taylor,

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Figure 1: Inside the Larkin Building, New York 1904



Figure 2: Osram Offices, 1963

1911; Turner & Myerson, 1998) influenced the design of several buildings including the Larkin Building in New York (Fig. 1).

As management theory evolved, the focus moved from the tasks carried out to employees' relationships with one another. The design of workplaces followed this trend with the introduction and popularity of open plan workplaces such as the Bürolandschaft design (fig 2).

Up until the 1980s, space standards were being quoted as 37-42 m² for directors to as low as 4.5-5.5 m² for administrative staff in the Metric Handbook (Fairweather & Silwa, 1977). Current design guidance is given as net internal area per person which includes circulation spaces. In the United Kingdom it is between 12m² and 17m². This indicates a more equitable space allocation which may be associated with less hierarchical management structures (British Council for Offices, 2000). The increase in the number of open plan workplaces since the 1960s has led to empirical evaluation of the impact of open plan space upon occupants. In general, these evaluations revealed a decrease in satisfaction levels and perceived productivity levels (Oldham and Brass, 1979; Brennan *et al.*, 2002; Becker *et al.*, 1983).

Due to the established research tradition of the more quantitative environmental conditions within the workplace, there are more well-supported theories.

Environmental conditions refer to the thermal factors and illuminance. Based upon research, industry standards have been developed to offer designers guidance on creating a workplace environment that is both safe and comfortable. Thermal guidance recommends that air temperature should be between 20°C and 26°C, and relative humidity between 30% and 70% (American Society of Heating Refrigerating and Air-conditioning Engineers, 2002). There has been a significant amount of research to suggest that moderate changes in thermal conditions have no impact upon productivity (Chiles, 1968; Lorsch & Abdou, 1994). However, alternative evaluation of the effect of thermal conditions revealed that participants' performance on a task increases at temperatures which are slightly cooler than those at which they report feeling most comfortable (Abdou & Lorsch, 1994; Nelson *et al.*, 1984).

Standards relating to illuminance levels are given by the Chartered Institute of Building Services Engineers (CIBSE, 1999) who recommend a level of 500 lux in general workplaces with the a range of acceptable illuminance being specified as 300 -

800 lux. Empirical research has not supported a link between moderate variations in illuminance and productivity (Nelson, Nilsson and Johnson, 1984; Boyce, 2003). Closely associated with illuminance is the provision of windows. Workplace users have consistently reported a strong preference for environments with windows. Their positive impact has been attributed to the variation in the quality of illuminance from daylight (CIBSE, 1999; Heerwagen & Heerwagen, 1986) and view (Sundstrom, 1986). In relation to productivity, there is again a lack of consistency with some researchers finding that a direct view out of a window improved performance (Stone & Irvine, 1994) whilst others found there was no decrease in productivity in a windowless room (Stone, 1998).

The qualitative aspects of the workplace are more difficult to measure objectively and therefore data collection generally takes the form of personal accounts. The lack of standardised methods of measurement has led many researchers to avoid evaluating these elements of the workplace and the results of analyses are inconclusive. One qualitative factor, the colour scheme, is the focus of a limited amount of research. Certain colours were found to have both a positive and negative impact upon productivity (Kwalleck & Lewis, 1990; Stone & English, 1998). Other qualitative variables such as break area provision, the presence of artwork and the amount of choice occupants had in the design of the workplace have been the subject of much speculation. However, there is little empirical research into each of these variables and it has not been possible to draw any conclusions.

A final issue that needs to be re-assessed is that design guidance prescribes environmental conditions which are comfortable. However, research has tended to show that being slightly uncomfortable can increase performance of a task. This has been demonstrated with higher performance recorded in environments perceived to be cool (Abdou & Lorsch, 1994) and slightly too bright in colour (Stone 2002). The researchers involved have concluded that feeling slightly uncomfortable is stimulating. This higher level of stimulation is thought to increase peoples' ability to perform a task, when a feeling of comfort may have lowered their levels of stimulation and reduced their productivity.

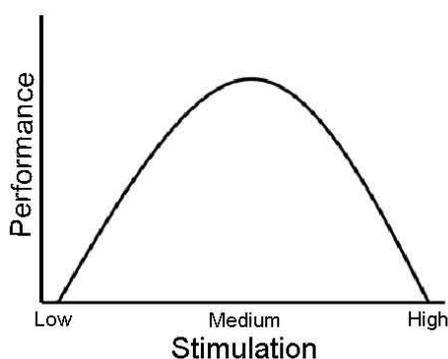


Figure 3 Yerkes-Dodson Principle

Stimulation and performance of a task have been found to be correlated and the relationship follows a pattern known as the Yerkes-Dodson principle (1908). Research has demonstrated that there is an optimal level of stimulation at which people perform a task to the best of their ability. This principle is illustrated in figure 3.

Performance of a task is worst at very low or very high levels of stimulation. The optimal level is at a point between these two extremes. The exact point depends upon the complexity of the task and the personality of the person performing the task. A more difficult task requires a lower level of stimulation, conversely, a task that requires little cognitive effort will be performed better at a higher level. Research into cognitive performance at varying times of the day has produced mixed results.

Studies have revealed that as body temperature increases, indicating a rise in stimulation levels, performance improves (Gupta, 1990). Body temperature follows a curve across a 24 hour period and peaks, on average, at 2000 hours. Obviously this peak varies according to individual differences and circumstances, although a similar pattern has been found in both introverts and extroverts (Wilson, 1989) and across different age groups (West *et al.*, 2002). Evaluation of performance of cognitive tasks in relation to temperature has supported this data with performance peaking for many participants at 1900 hours and the worst performance being recorded at 0900 hours (Gupta, 1990).

However the general perception that performance of cognitive tasks declines in the afternoon yielded a different theory. Thorndike (1900) proposed that mental fatigue builds throughout the day at work, thus people feel less alert and stimulated in the afternoon due to mental exertion. Potter and Keeling (2005) found performance of a cognitive task worst at 15:00hours compared with results obtained at 09:30hours, 12:30hours and 18:30hours. The best performance was obtained at 09:30hours.

The inconsistency in the research findings may be due to the differences between physical and perceived stimulation. Folkard (1983) plotted the data from a series of studies to reveal the differences between body temperature throughout the day, which was given as the actual level of stimulation, and perceived level of stimulation (see Figure 4).

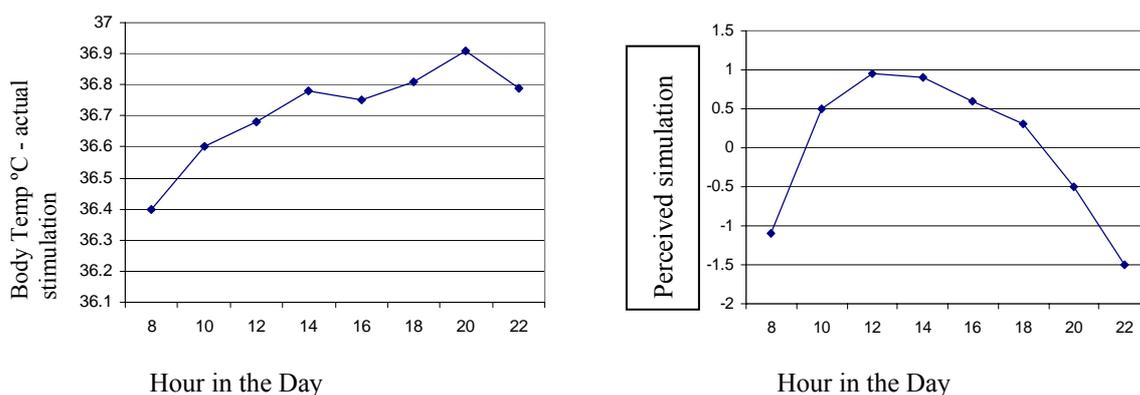


Figure 4 Actual and Perceived Stimulation in Relation to Time of Day (Folkard, 1983)

The difference between these graphs demonstrates that perceived stimulation is not correlated with physiological measures. The significant relationship with productivity could be due to the difference between actual and perceived levels of stimulation. Researchers have theorised that productivity is influenced by people’s perception rather than their actual level of stimulation determined by physiological methods. West *et al.* (2002) found that there was no significant difference in the daily

fluctuation of body temperature of both old adult and young adult participants but their perceived level of stimulation differed significantly. Older adults perceived their stimulation levels to peak in the morning whilst young adults rated themselves as being most stimulated in the early evening. It was this self-rating that was found to be significantly correlated with measurements of efficiency of working memory. Hull *et al.* (2003) found that participants in their study performed best when their perceived levels of stimulation and motivation were at their highest. There was no effect of circadian rhythms and number of hours awake that are traditionally used as measures of actual stimulation.

The aim of this research is to investigate what factors in the workplace environment impact upon user perceptions. The hypothesis tested was that the workplace environment would have a significant impact upon satisfaction, perceived stimulation and perceived productivity. A second hypothesis was that changing certain aspects of the environment would have an impact upon perceived stimulation.

METHODOLOGY

To gain a full understanding of the impact of the working environment, it is essential to assess all aspects of the workplace holistically. To achieve this, a methodology comprising five different processes was devised. The first of these processes was developed to enable measurements of the indoor climate to be taken. The methods for measuring air temperature, air movement, relative humidity, sound and illuminance are well established and equipment was easily identified with which data could be collected. Data relating to spatial layout was also collected using detailed layout plans. The objective measurements of the more qualitative variables (ie decoration, window provision and furniture provision) were collected, using standardised observational reports and digital photographs. A questionnaire was designed to collect data regarding the subjective experience of workplace users. The questionnaire enabled the collection of data relating to the participants' work and their perceptions of all aspects of the workplace environment. Satisfaction, perceived stimulation and perceived productivity were the dependant variables.

Several methods of identifying productivity were evaluated but with such varied organisations taking part, from chemical manufacturers to accountancy firms, there was no common measure of productivity. Therefore, perceived productivity has been selected. Whilst research has shown that there is a pattern of people over-estimating their own productivity levels, there is a significant correlation with actual productivity (Oseland, 1999). Participants were also asked to record how many days they had been absent from work in the last six months.

The methodology selected and developed for this paper is as rigorous as possible due to the current state of knowledge. The factors that are easy to measure objectively, and that have been subjected to a greater amount of empirical analysis, can be evaluated using well-established research methods. These factors are primarily the indoor environmental factors and some of the spatial aspects. The variables selected which are more qualitative have not received as much empirical research attention. This lack of data and the absence of any robust and well established research methods has meant that the results are to some degree pragmatic until the research methods have been established as rigorous measurements of the qualitative factors.

Twenty workplaces designed by architectural practice RyderHKS were selected and approached to take part in this study as a consistent design process followed in the

development of all the buildings. The participating workplaces were all completed within the last 1-5 years. Within each workplace a random sample of 30 users was taken which yielded more than 500 datasets. The environmental data was collected at the desk of each participant in both the morning and the afternoon, to account for any variation in conditions throughout the day. Observational reports were also completed at each desk. The return rate of the questionnaires was 87%.

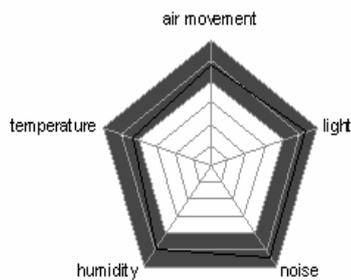


Figure 5: Occupant Perceptions of Indoor Climate

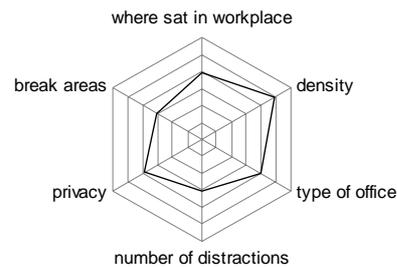


Figure 6: Occupant Perceptions of Spatial Layout

RESULTS

The data was analysed to determine occupants' perceptions of the workplace and evaluated in relation to satisfaction, perceived stimulation and perceived productivity. The data collected from occupants about each aspect of the workplace using the questionnaire was plotted on a series of graphs. Figure 5 reveals how occupants on average perceived the indoor climate of their workplaces.

The shaded area represents the comfort zone or acceptable level of satisfaction in which the occupants' perceptions, represented by the black line, should fall if they are satisfied with that aspect of the environment. The results show participants overall were satisfied with all aspects of the indoor climate.

Figure 6 is the graphical representation of the data collected from occupants in relation to the spatial layout of the workplace.

Again the shaded area represents minimum acceptable level of satisfaction with that aspect and the black line denotes occupant perceptions. Figure 6 reveals that occupants in general were satisfied with the density of their workplaces. Where participants were located, the type of office in which they worked and the amount of privacy they had were all borderline satisfactory. Finally, break areas and the number of distractions were overall considered to be unsatisfactory. Finally, figure 7 is the radar plot of data collected from participants in relation to the qualitative aspects of the workplace.

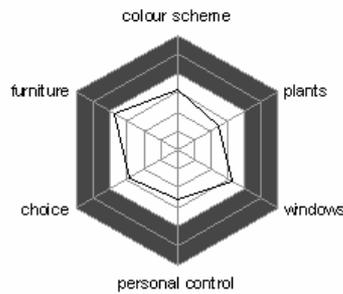


Figure 7: Occupant Perceptions of the Qualitative

Figure 7 demonstrates that occupants overall were dissatisfied with all features of the workplace. The data reveals occupant perceptions are not within the boundaries of the shaded area (the acceptable level of satisfaction).

A series of stepwise regressions were performed between participant's perceptions of satisfaction, perceived stimulation and perceived productivity as the dependent variables and all other measures as the independent variables.

Satisfaction

Results of this analysis show five of the independent variables contributed significantly in predicting satisfaction in the workplace: choice, spatial layout, personal control, break areas and density of the workplace ($F(13,259) = 19.606$, $p < 0.001$). The model explained 47% of the difference in overall satisfaction with the workplace between participants.

Perceived Stimulation

Results of this analysis show six of the independent variables contributed significantly in predicting perceived stimulation in the workplace: choice, personal control, spatial layout, break areas, decoration and air movement ($F(13,259) = 19.522$, $p < 0.001$). Coincidentally, this model also explained 47% of the total variance between participants in perceived stimulation.

Perceived Productivity

Results of this analysis show two of the independent variables contributed significantly in predicting perceived productivity in the workplace: personal control and decoration ($F(2,270) = 8.769$, $p < 0.001$). The model explained 5% of the total variance in perceived productivity levels of the participants.

DISCUSSION

The results from this study show participants were satisfied with all aspects of the indoor climate. However, when evaluated in relation to the objective measures, few significant correlations were found. The only variable for which the objective and subjective data were consistently correlated was air velocity. These results suggest that variation of the physical environment would have little impact upon the perceptions of workplace users, as they would be unable to detect changes provided

they remain within steady-state parameters that form a comfort zone. However, the variation in each of these variables measured within these environments was moderate. More significant correlations may have been recorded if there had been greater variation in the variables, which were easier for participants to detect.

Quite different results were obtained when evaluating participant perceptions relating to the spatial layout of the workplace. Generally, the spatial layout was perceived to be satisfactory for type of office and density. The majority of occupants were located in open plan workplaces. Participants were dissatisfied with the break areas and number of distractions within their workplace environment. They were slightly dissatisfied with where they were located and the amount of privacy they had. This result was obtained as some occupants were satisfied, but a slightly higher proportion of workplaces were rated as being dissatisfactory in relation to these variables. Working in open plan offices appeared to increase the amount of social interaction with colleagues.

The final aspects evaluated were those more associated with interior design or features of the workplace. Analysis of the subjective data relating to personal control, windows, plants, colour scheme, and furniture demonstrated that participants were not satisfied with any of the variables measured. This implies that designers are failing to provide workplaces that meet all of occupants' needs and expectations. However, there were several significant relationships found between the measurements and participants' perceptions. The number of colours participants could see from their desks was significantly related to their perception of the attractiveness of the workplace decoration. Both a greater number of plants and a greater number of pieces of artwork were correlated with participants' positive perceptions of these aspects. A positive correlation was also recorded between the amount of control participants had over the physical environment and their satisfaction with this level of control. As all these aspects were perceived to be significantly below the level of satisfaction a maximum level of artwork, plants and control cannot be determined from these results.

The results of this study reveal when considering levels of satisfaction and perceived stimulation in the workplace environment variables other than objective need to be considered. Subjective variables such as personal control, choice and spatial layout need to be measured. Two variables contributed significantly to perceived productivity in the workplace: personal control and decoration. However only 5% of the variance was accounted for in this analysis and therefore it would be inappropriate to draw any definite conclusions at this stage. Additional influences upon productivity at work such as type of work, management and relationships with co-workers might also account for large proportions of the variance in perceived productivity. Furthermore, the variance in perceived productivity was obtained without any specific changes being made to the workplaces to affect the productivity levels of employees.

FURTHER RESEARCH

Data from the first study was evaluated and participants self assessment of the time of day when they were most alert was plotted on a graph (See Figure 8).

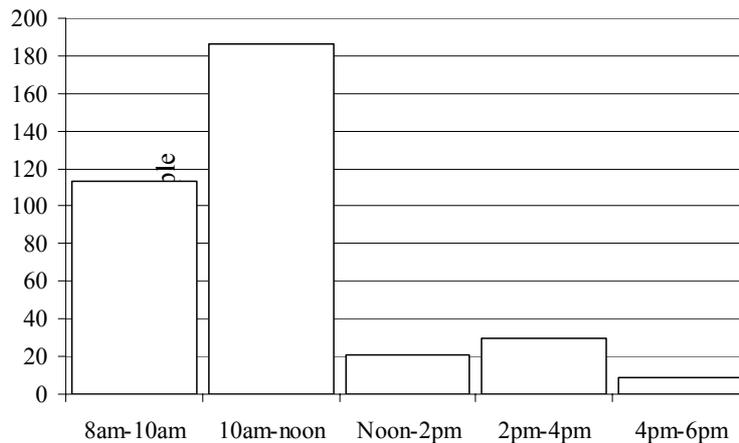


Figure 8 Time of Day at Which Participants Felt Most Alert

Figure 8 reveals that participants perceived themselves during the working day to be most alert in the morning and least alert in the afternoon. Further analysis of the data confirmed that stimulation was a significantly correlated with perceived productivity ($r(296) = 0.292, p < 0.001$).

To test the impact that changing specific aspects of the environment has upon workplace occupants, a pilot study is currently underway within two nominated areas of the RyderHKS workplace. The twelve occupants of one workspace have been allocated to the control condition and another eight occupants located in another workspace have been allocated to the control condition. Participants from both conditions were told that they were taking part in a study assessing the impact of the workplace environment.

During the experimental phase seven aspects of the workplace will be varied to assess their impact upon stimulation levels; temperature, air movement, illuminance, colour scheme, artwork, social interaction and privacy. These variables are to be kept constant in the morning at levels and manipulated one at a time in the afternoon. As changes to the workplace are implemented, a short questionnaire about perceived stimulation will be completed by participants in both conditions.

CONCLUSIONS

Overall findings from the current research reveal when considering satisfaction, stimulation and perceived productivity within the workplace environment, focusing on indoor climate and objective measures is not sufficient. Designers need to be aware of how subjective variables such as personal control and choice can subtly enhance perceived levels of satisfaction, stimulation and productivity. All aspects of the workplace were found to be correlated with the dependent variables satisfaction and stimulation which were themselves significantly correlated with perceived productivity. Creating environments that have a positive impact upon those who occupy them requires thorough and holistic evaluations of varying workplaces to be conducted. Only through analysis of this data will a fuller understanding of the impact of workplaces be achieved.

Findings from the second study evaluating how the workplace can be changed to affect occupants' stimulation levels throughout the day should add to the current state of knowledge. It should provide further evidence supporting the hypothesis that the design of workplaces can have a positive impact upon occupants and the performance of an organisation overall.

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