

Windows and Offices: A Study of Office Worker Performance and the Indoor Environment – CEC PIER 2003

This study reports on an investigation into the influences indoor physical environment has on office worker performance. It is particularly concerned with the potential contributions of windows and daylight to improved performance by office workers. Two different studies were conducted at the same organization, the Sacramento Municipal Utility District. The first study looked at 100 workers in an incoming call center, whose performance was continuously tracked by a computer system and measured in terms of time to handle each call. The second study examined the performance of 200 other office workers on a series of short cognitive assessment tests, taken at each individual's desktop computer.

The study sites provided a range of daylight, view and ventilation conditions, while providing a relatively uniform environment for other potential influences on worker performance. All of the office work considered was computer-based, based on self-illuminated tasks. Extensive data was collected about the physical environment at each office worker's cubicle. Multivariate regression analysis was used to control for other potential influences, such as age or employment status. A variety of statistical models were tested to determine if any of the variations in environmental conditions, either between workers or during different time periods for a given worker, were significantly associated with differences in worker performance.

The studies found several physical conditions that were significantly associated ($p < 0.10$) with worker performance, when controlling for other influences. Having a better view out of a window, gauged primarily by the size of the view and secondarily by greater vegetation content, was most consistently associated with better worker performance in six out of eight outcomes considered. Workers in the Call Center were found to process calls 6% to 12% faster when they had the best possible view versus those with no view. Office workers were found to perform 10% to 25% better on tests of mental function and memory recall when they had the best possible view versus those with no view. Furthermore, office worker self reports of better health conditions were strongly associated with better views. Those workers in the Desktop study with the best views were the least likely to report negative health symptoms. Reports of increased fatigue were most strongly associated with a lack of view.

Other variables related to view were also found significant. In the Call Center higher cubicle partitions were associated with slower performance. In the Desktop study glare potential from windows was found to have a significant negative effect on performance in three of the five mental function assessment tests. In the three tests, the greater the glare potential from primary view windows, the worse the office worker performance, decreasing by 15% to 21%, all other things being equal.

Horizontal daylight illumination levels were found to have an inconsistent relationship to performance, significant in two out of eight metrics tested. Higher levels of daylight illumination were found positive for Digit Span Backwards, a test measuring attention span and short term memory, and negative when compared to changes in daily average speed of handling calls for one of two study periods. The natural log of daylight illumination levels was found to have the best mathematical fit to the data, implying more sensitivity to changes at lower levels of illumination and progressively less sensitivity at higher levels.

Ventilation status and air temperature were also found to have significant, if intertwined and occasionally contradictory, associations with worker performance. When variation in hourly performance at the Call Center was considered, higher rates of outside air delivery were significantly associated with faster handling of calls.

Overall these potential influences on worker performance were found to have high statistical significance in the models tested. They are related to performance that is 1% to 20% better or worse than average. All together information about the physical conditions of the workers was able to explain about 2% to 5% of the total variation observed in a measure of worker productivity (Call Center study) or in performance on short cognitive assessment tests that were thought to be related to worker productivity (Desktop study).

Even small improvements in worker productivity are of great practical importance, and explaining 2%-5% of total variation is not trivial. By way of comparison, all other available information typically believed to predict performance such as demographic characteristics or employment status was able to explain about 6% to 19% of the variation in their performance. Thus the characteristics of the physical environment represent about 1/8th to 1/3rd of our entire ability to predict variation in individual worker performance.

Furthermore, changes in the physical design of a space that may influence worker performance are likely to have great persistence, continuing for the life of the building. When compared with the costs, persistence and the certainty of other methods of increasing productivity, constructing well-designed buildings may be attractively cost-effective. As demonstrated in the study site, these same features can also provide additional energy cost savings.

Both studies successfully measured variation in office worker environmental conditions and related these to measured office worker performance under actual employment conditions. The Desktop study pioneered the use of computerized cognitive assessment tools to gauge office worker performance in field conditions. The studies have shown that indoor environmental conditions can have a measurable relationship to changes in office worker performance and have established a range of likely effect sizes that other researchers can use to refine the needs of future studies. Other studies will be required to test if these findings can be replicated in other settings and to explore potential causal mechanisms between the environmental conditions and worker performance.