Bringing Nature to Work:

Preferences and Perceptions of Constructed Indoor and Natural Outdoor Workspaces

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Abstract

From the mere presence of plants to window views of nearby nature, contact with nature in the workplace has been associated with increased productivity and creativity, as well as positive emotional and physical health outcomes. Nevertheless, if nature is to be incorporated within or near workplaces effectively, it is important that workers perceive natural spaces to be conducive, and not detrimental, to performance on activities that they may engage in at work or else these changes to the physical environment may not be fully embraced by workers. Thus, in the current research we examine workers' preferences and perceptions of different natural and constructed (built) environments for different workplace activities. In Study 1, 64 knowledge workers were exposed to images of natural outdoor and constructed indoor workspaces. They selected where they thought they would best and least be able to perform different workplace activities. Natural outdoor spaces were overrepresented as the best spaces for around 75% of the workplace activities, and were underrepresented as the worst spaces across all workplace activities. In Study 2 (N = 33), wherein participants evaluated various spatial qualities of the natural outdoor and constructed indoor space types that were included in Study 1, the natural outdoor spaces were rated as more fascinating, relaxing, open, bright, and quiet. The results of this research project suggest that natural outdoor workspaces are viewed as highly flexible, multi-use spaces that are appropriate for diverse workplace activities. Furthermore, access to diverse workspace types with different spatial qualities appears to be highly valued.

Keywords: biophilic architecture, nature, nature type preference, office design, worker performance, workspace

1. Introduction

Workplaces are one of the most common types of physical environments that individuals inhabit in their daily lives, with full-time workers spending approximately one-fifth of their time each year working (Organisation for Economic Co-operation and Development, n.d.). Far from inconsequential, the physical environment that surrounds workers can have a considerable impact on their work performance (e.g., Brill, Margulis, & Konar, 1985; Clements-Croome, 2000; Vischer, 2007). Furthermore, whether certain physical environments improve or impair worker performance critically depends on the specific activity at hand (Meusburger, 2009). For instance, existing research suggests that open, spacious settings are more conducive to work that involves abstract, relational, and creative thinking (Leung et al., 2012; Meyers-Levy & Zhu, 2007), as well as communication and collaboration, while enclosed, private spaces appear to be superior when work requires high levels of focus with minimal distractions (Vischer, 2008). These findings are echoed in a review of previous research by Davis, Leach, and Clegg (2011); conducting complex tasks in isolation increases task performance, and provides creative workers opportunities to avoid overstimulation and other environmental stressors associated with non-private workspaces. The effects of other spatial qualities, such as color (e.g., Lichtenfeld, Elliot, Maier, & Pekrun, 2012; Mehta & Zhu, 2009), have also been found to depend on the type of activity that is being conducted. In general, existing research indicates that spatial qualities can influence worker performance. Moreover, the degree of influence and suitability of individual physical environments on worker performance appears to vary for different workplace activities. For the purpose of this article, we limit our focus to knowledge workers and the activities that they commonly engage in at work, as they make up a considerable portion of workers in developed nations (McCoy, 2002).

Beyond the built aspects of physical environments, researchers have also examined how access to nature can influence worker performance, well-being, and comfort. Several theories, in fact, can help one understand why contact with nature should be beneficial for workers. From the perspective of attention restoration theory (Kaplan & Kaplan, 1989), natural spaces are thought to serve as restorative environments due, in part, to their ability to effortlessly engage one's attention, and to give executive functions a rest and the opportunity to recover. Even brief instances of respite (e.g., looking out the window at a tree or at a plant indoors) may be able to offer what Kaplan (1993) refers to as micro-restorative experiences or what Lee, Williams, Sargent, Williams, and Johnson (2015) refer to as micro-breaks. Thus, natural spaces and elements should be able to improve concentration, as well as alleviate some of the negative affective consequences that can be experienced when executive functions are taxed (Kaplan, 1995), by providing opportunities for restoration between and during work tasks.

Along with offering people a sense of purpose and identity, work can also be a significant source of stress (e.g., Michie, 2002). According to stress-reduction theory (Ulrich et al., 1991), exposure to non-threatening nature should help reduce this stress. Similar to research suggesting that people are biologically prepared to respond negatively to things that would have been a threat in our evolutionary history (e.g., snakes; Öhman, 1986), proponents of this theory argue that we have developed a fairly automatic, immediate, and positive response to natural environments and elements that would have been conducive to our survival and well-being. Ulrich et al. (1991) theorize that this would have also allowed for a quicker recovery from stressors and shift from avoidance to approach behaviors. Based on this, natural spaces and elements within or near the workplace should help buffer the psychophysiological manifestations of the stress response in workers, and move them toward a level of arousal that is more optimal

for performance (e.g., Yerkes & Dodson, 1908).

The biophilia hypothesis (Wilson, 1984) takes a similar psycho-evolutionary approach and argues that because so much of our evolutionary history was spent intimately living in and interacting with nature, a need to connect with nature persists to this day. It follows that greater well-being should be experienced when this need is satiated, while a disconnection with the natural world should be detrimental to flourishing. From this perspective, by providing opportunities for workers to connect with nature at work, they should feel happier, and more satisfied and engaged.

The published research generally supports these theoretical predictions. For instance, studies show that workers who have windows overlooking nearby nature (e.g., trees) report greater job satisfaction, and better physical health and mental well-being compared to workers without these views (e.g., Gilchrist, Brown, & Montarzino, 2015; Kaplan, Talbot, & Kaplan, 1988; Kaplan, 1993). Similarly, individuals rate access to natural light at work as highly desirable (e.g., Wineman, 1982) and total time spent in natural environments near work has been shown to be positively associated with mental well-being (Gilchrist et al., 2015). Recent research by Bjørnstad, Patil, and Raanaas (2016) found that workers with greater amounts of indoor nature contact at work tend to report lower levels of job-related stress, fewer subjective health complaints, and fewer days off of work due to illness compared to employees who work in more nature-impoverished environments. Likewise, Largo-Wight, Chen, Dodd, and Weiler (2011) showed that perceptions of overall health and stress are improved among employees who report greater exposure to nature at work, although this specific finding was largely driven by outdoor nature contact. These improvements in psychological and physical well-being should be attractive not just to workers, but also employers, since people tend to be more productive and

satisfied with their job when they are happy and healthy (e.g., Faragher, Cass, & Cooper, 2005; Merrill et al., 2013; Zelenski, Murphy, & Jenkins, 2008). Along with improved physical, psychological, and social well-being, existing research indicates that access to nature at work benefits worker performance on a variety of tasks. For instance, researchers have found that the presence of plants can increase productivity and creativity (e.g., Atchley, Strayer, & Atchley, 2012; Hesselink et al., 2008; Knight & Haslam, 2010; Lee et al., 2015; Lohr, Pearson-Mims, & Goodwin, 1996; Marchant, 1982; Nieuwenhuis, Knight, Postmes, & Haslam, 2014; Shibata & Suzuki, 2004; but see Larsen, Adams, Deal, Kweon, & Tyler, 1998 for contradictory results). The presence of vegetation has also been shown to improve occupants' overall comfort, as well as thermal comfort, space use rates, and perceptions of the quality of the physical environment (e.g., air quality, acoustics, visual comfort, and light levels; Bergs, 2002; Fjeld & Bonnevie, 2002; Hellinga & de Bruin-Hordijk, 2010; Hesselink et al., 2008; Mangone, Kurvers, & Luscuere, 2014; Stiles, 1995; Vink, Groenesteijn, Blok, & de Korte, 2008).

More generally, numerous studies have found that individuals tend to prefer nature scenes over images of constructed (built) environments (e.g., Dopko, Zelenski, & Nisbet, 2014; Hartig, Böök, Garvill, Olsson, & Gärling, 1996; Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Wendt, 1972; Ulrich, 1981; Van den Berg, Koole, & van der Wulp, 2003). Moreover, brief nature contact (e.g., walking in or viewing photographs of natural environments) has been shown to lead to greater emotional well-being (see meta-analysis by McMahan & Estes, 2015), enhanced ability to reflect on life problems (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2008), and cognitive restoration when mentally fatigued (e.g., Berman, Jonides, & Kaplan, 2008; Berto, 2005; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Hartig & Staas, 2006; Kaplan, 1995; Van den Berg et al., 2003). Recent research even suggests that interactions with nature

may promote cooperative and sustainable behaviors (e.g., Guéguen & Stefan, 2014; Weinstein, Przybylski, & Ryan, 2009; Zelenski, Dopko, & Capaldi, 2015). The positive benefits of nature contact is also evidenced in research on the Japanese practice of shinrin-yoku (i.e., forest bathing; Tsunetsugu, Park, & Miyazaki, 2010), where immersion in natural environments has been shown to improve mood (e.g., Miyazaki et al., 1995 ; Morita et al., 2007; Park et al., 2011) and immune system functioning (e.g., Li et al., 2007, 2008a, 2008b), and lower physiological indexes of stress (e.g., Miyazaki et al., 1995; Tsunetsugu et al., 2007). Moreover, depending on the design solution, incorporating natural environments and elements into office buildings can reduce construction and operating costs, as well as building and occupant resource consumption rates (Hellinga & de Bruin-Hordijk, 2010; Mangone et al., 2014; Mangone & van der Linden, 2014; Mangone, 2015; Romm & Browning, 1994; Terrapin Bright Green, 2012). Thus, bringing nature to the workplace appears to have the potential to foster diverse benefits for employers, employees, and the environment.

Despite the growing evidence for the multitude of benefits that personal interaction with nature can bring (see reviews, for instance, by Capaldi, Passmore, Nisbet, Zelenski, & Dopko, 2015, and Tzoulas et al., 2007), individuals within western societies spend more than 80-90% of their time indoors (European Commission, 2011; Evans & McCoy, 1998; MacKerron & Mourato, 2013; Matz et al., 2014). Moreover, people worldwide are increasingly living in urban environments (United Nations, 2014), where opportunities to connect with nature and reap its benefits tend to be minimal. This constructed separation between urban communities and natural environments (Mangone & Teuffel, 2011) has led a number of researchers to propose that nature should be integrated into urban landscapes, public spaces, and buildings, in order to make the places we now frequently inhabit contain more natural elements, and thereby, more

psychologically beneficial. For instance, based on Wilson's (1984) biophilia hypothesis, proponents of biophilic architecture suggest that incorporating nature into constructed environments helps satisfy our innate need to interact with other living entities and life processes which developed over the course of our evolutionary history (Kellert, Heerwagen, & Mador, 2008). Joye's (2012) emotion-based approach, rooted more in restoration research (e.g., Hartig & Staas, 2006; Kaplan & Kaplan, 1989), builds off of the fact that natural environments and events are particularly adept at eliciting a broad range of positive emotions. Joye posits that architecture can be made more aesthetically pleasing and restorative by integrating and mimicking aspects of nature that typically produce positive feelings such as awe and fascination. An even broader and more inclusive approach labelled restorative environmental design propounds that constructed environments should be designed to be restorative not only psychologically, but ecologically and bioculturally as well (Hartig, Bringslimark, & Patil, 2008; Kellert, 2005). Specifically, advocates of this approach argue that constructed environments should be designed in a way that minimizes their impact on the natural world (e.g., lower resource consumption) in order to allow for the restoration of the ecosystem. Moreover, according to restorative environmental design, these eco-friendly constructed environments should also incorporate nature to maximize attention and stress recovery (i.e., psychological restoration), and re-establish people's connection to nature (i.e., biocultural restoration).

To this end, natural environments are already being incorporated inside and adjacent to some office buildings, such as the atrium of the Ford Foundation in New York City, the atrium of the Sun Life Financial Building in Ottawa, Canada, the indoor nature courtyards in the Lumen research building in Wageningen, the Netherlands, and the atrium of the Ministry of Finance in Den Haag, The Netherlands. However, existing office buildings with adjacent or interior natural

environments tend to be designed from an aesthetic, rather than a work performance or employee satisfaction perspective. This is partly because existing research on the cognitive, affective, and physical health benefits of natural elements and environments to office workers tend to provide general results, instead of specific results on effective natural environment types and spatial qualities that can be used as design strategies by professionals (Mangone, 2015). For instance, although numerous studies have examined people's general, decontextualized preferences for natural environments, there is a dearth of published studies that have investigated perceptions of the suitability of different natural environments for a wide range of workplace activities. If natural elements and environments are to be incorporated within or near the workplace in ways that improve worker performance and satisfaction, it is important to determine what types of natural environments and elements workers perceive to be ideal, or even appropriate, for the activities they commonly engage in during a typical work day.

Rather than assuming that natural environments will be seen as uniformly beneficial for all workplace activities, we investigate people's preferences for different types of natural outdoor spaces for seventeen different work activities in Study 1. Instead of manipulating individual elements of the physical environment in an isolated and reductionist manner, we chose to take a more holistic approach and broadly compared natural outdoor spaces to constructed indoor spaces that are traditionally found within the workplace. In Study 2, we assessed the different spatial qualities of the natural outdoor and constructed indoor spaces to explore why participants' space preferences might have differed across workplace activities.

2. Study 1

2.1. Method

2.1.1. Participants

Sixty-four individuals from a university in the Netherlands who spend at least half their work time devoted to research (i.e., doctoral students, full-time researchers, and professors) were recruited to participate in Study 1. Individuals were deliberately recruited from departments that regularly study and think about the function and form of physical environments (i.e., architecture, architectural engineering and technology, real estate and housing, and urbanism) as we wanted experts who could effectively imagine the spaces to try to predict, as accurately as possible, how well they might perform workplace activities in each. In addition, the building that all the departments were located in had a wide range of constructed workspace types available, giving participants ample opportunity to accumulate experiences working in a variety of spaces. A stratified sampling approach was employed to ensure that members from each department were proportionally represented in our sample. The sample contained more men (n = 40) than women (n = 24), and the mean age of participants was 41.6 years (SD = 11.16). The demographic characteristics of our sample were similar to that of the wider population of individuals who worked within the building. Informed consent was obtained from participants in both studies.

2.1.2. Materials

2.1.2.1. Constructed Indoor Workspace Images

In order to identify appropriate workspace types to include in the study, we reviewed the various workspace types that have been developed in previous projects and outlined in the existing literature (e.g., Danielsson & Bodin, 2008; Duffy & Powell, 1997; Mattke, Schnyer, & Van Busum, 2012; Lagorio-Chafkin, 2014; Veldhoen, 1995). Through this review, we determined that a comprehensive evaluation of existing constructed workspace types should include conventional workspace types (e.g., open-plan workspaces, cellular workspaces, and

formal conference rooms), as well as more recent flexible and activity-based workspace types (e.g., cafes and informal meeting spaces). The latter are important to include as flexible and activity-based workspace types are increasingly being incorporated into the office environments of knowledge workers throughout the world (Colliers International, 2012; Lagorio-Chafkin, 2014). This review process resulted in the identification of ten different constructed indoor workspace types that were found to be representative of the typical workspaces that are available to knowledge workers.

2.1.2.2 Natural Outdoor Workspace Images

In order to compare these constructed indoor workspaces to more natural spaces, five different types of nature spaces were identified as well. The incorporation of multiple types of natural environments, including a meadow and dense forest, as well as more managed natural environments, including a typical park space and forest amphitheatre, allowed us to investigate the relative perceived performance potential of different types of natural environments that have different environmental stimuli and spatial qualities, as well as slightly different degrees of constructed elements and visual indicators of human management (e.g., wild growing trees, grass, and flowers vs. planted flowers and trimmed bushes and grass within a park).

Although the cave space was originally included in this study as a natural space, we decided that it was too different from the other natural spaces to be placed in the same category. The cave space is more of an indoor environment with a lot more constructed elements and a lack of vegetation compared to the other four natural spaces that are all outdoors and contain an abundance of greenery. Spatial quality ratings in Study 2 supported this decision. Thus, when we discuss natural outdoor spaces in this research, we are referring to the meadow, dense forest, park, and forest amphitheatre images.

2.1.2.3 Workspace Image Selection Process

The inclusive approach we took in the identification of workspace types allowed for a more comprehensive understanding of the perceived performance potential of the diverse array of constructed and natural workspace types that can be developed for office environments. A representative image was selected for each space type, resulting in ten images of constructed workspaces (see Fig. 1) and five images of natural workspaces (see Fig. 2). Extraordinary images of natural and constructed spaces were avoided in order to reduce the potential for participants' responses to be unduly influenced by any extraordinary elements in the image (e.g., excessive colors, flowers, or expensive furniture) instead of the space type itself. Various images were evaluated, removed, added, and reassessed in a pilot study with 10 participants to ensure that each image was perceived as being representative of their respective space type. Images were used in this study because they allowed us to examine a wider range of workspaces than would have been feasible to test if participants were evaluated while occupying existing constructed and natural environments. This is especially relevant when one considers the general paucity of accessible natural environments in and around existing office buildings, as well as the fledgling state of this particular line of research.

One may notice by how we have labelled the two main types of spaces under investigation that the spaces not only differed on whether they were of natural or constructed environments, but also by whether they were outdoors or indoors. This confounding of nature/outdoors and constructed/indoors is common in many existing studies on the psychological benefits of human-nature interactions (see Bringslimark, Hartig, & Patil, 2009) and may lead some to question the extent to which we can generalize our findings to nature incorporated within the workplace. We believe that these spaces may be appropriate proxies for

the type of indoor nature that motivated our interest in this line of research. Namely, “the recreation of outdoor nature indoors”, such as a microforest (Mangone, 2015) with indoor plants in “large numbers and with a large volume relative to the space” (Bringslimark et al., 2009; p. 428). Given the rarity of these types of immersive indoor natural environments, we relied on images of outdoor natural spaces in this initial investigation.

It should be noted that an additional image of a lecture hall with a window was available for participants to choose for two of the lecture and exercise activities. Since limited data was collected for these activities, we will not focus on this workspace in this paper. However, our analyses involving the lecture and exercise activities take the presence of this additional image into account.

2.1.2.4. Workplace activities

Seventeen workplace activities that knowledge workers typically engage in were identified from a review of the existing literature (e.g., Davis, Leach, & Clegg, 2011; Funke, 2009; Robinson, 2012; Treffinger, 1995). Special attention was given to identifying workplace activities that require different physical work environments, and involve different social norms and cognitive demands. One of the assumptions underlying restorative environmental design is that “cycles of stress and restoration are regulated by activity cycles” and that some activities “require that people mobilize resources to meet demands”, whereas other activities “allow for restoration of depleted resources” (Hartig et al., 2008, “The Social Ecology of Stress and Restoration”, para. 3). Thus, it was important to include a variety of activities to allow us to investigate whether preferences for natural spaces were restricted to workplace activities that provide opportunities for restoration or whether a biophilic preference is present for cognitively demanding activities as well. The workplace activities included administrative/non-technical

work, informal/casual meeting, formal/official meeting, listening to a lecture, exercising, taking a break, brainstorming, focus/technical work, reflecting, evaluating, and having lunch. The latter six workplace activities were further divided into activities completed individually or with others.

2.1.3. Procedure

Once participants arrived at the lab, they were informed that the goal of the study was to learn what kind of environments improve and reduce worker performance on a variety of workplace activities. To minimize socially desirable responses, participants were told that there were no right or wrong answers, that the researchers were not trying to prove a hypothesis, and that their responses would be confidential. After being presented with the 15 images, individuals were asked to order them by the space they would most prefer to occupy in general. Along with assessing general preferences, this task was intended to familiarize the participants with the space types. Participant familiarization with the images before assessing their preference of different space types for specific work activities was found to be important during a pilot study. When the initial familiarization question was not included in the first phase of the pilot study, several participants noted after evaluating the space types for one or two activities that they just noticed certain spatial qualities of the different images, which changed their perception and valuation of the space types. After introducing the familiarization question into the second phase of the pilot study, participants no longer raised this issue.

Participants were then asked to select and order the four spaces where they would best be able to engage in the given workplace activity, as well as the four spaces where they would least be able to engage in the given workplace activity. In order to encourage participants to select workspaces based on the space itself, and not based on issues such as convenience and

accessibility, they were told to imagine that the constructed and natural workspaces were equally accessible from their current location. Moreover, participants were instructed to imagine that the nature spaces were comfortable in terms of weather and, similar to the constructed indoor workspaces, contained all necessary utilities and furniture that they needed to complete the activity. These instructions were important to include because one of the primary goals of this line of research was to assess the benefits of integrating natural environments within office buildings (see Mangone, 2015). Since a number of potential issues regarding comfort, technology, and accessibility can be effectively addressed through the design of a microforest or other indoor nature-based environments, it was important to minimize the influence of these concerns on the ordering of workspaces. Finally, participants were also asked to rate their acoustic and privacy preferences for each workplace activity on 7-point scales ranging from 1 (*silent*; *completely private*) to 7 (*very noisy*; *very open and public*).

2.1.4. Analysis strategy

The proportion of natural outdoor spaces selected as the best four spaces for each workplace activity was coded for each participant. The cave space was not included in this proportion as it differed qualitatively from the other four natural outdoor spaces (see Study 2). An average sample proportion was calculated for each workplace activity and compared to the proportion expected if there was no overall preference using a one sample *z*-test. A similar analysis strategy was employed for the proportion of natural outdoor spaces selected as the worst four spaces for each workplace activity.

2.2. Results

As illustrated in Table 1, natural outdoor spaces were overrepresented as the best four workspaces for the majority of workplace activities. Participants were significantly more likely

to select natural outdoor environments as spaces where they could brainstorm, reflect, and evaluate, alone or with others, to the best of their ability. Natural outdoor spaces were also disproportionately chosen as the best spaces for informal meetings, breaks, lunches, and exercise. The only exceptions to this pattern were for administrative and focus/technical work, and formal meetings, where natural outdoor spaces were not selected more/less than one would expect if there were no overall preferences.

For a somewhat different and more fine-grained examination of individual spaces, the workspaces that were most commonly perceived as being the absolute best space for each of the workplace activities (i.e., placed in the number one slot) are presented in Table 2. If a workspace is in the most popular column for a workplace activity in Table 2, it means that more people selected it as the absolute best workspace for that activity; if a workspace is in the second most popular column for a workplace activity, it means that it had the second most people select it as the absolute best workspace for that activity; and so on for the third most popular column. The meadow and dense forest spaces were among the three most popular choices for fourteen of the workplace activities, with the forest amphitheatre following close behind with ten. Although some of the constructed indoor workspaces like the cellular office, formal meeting room, and open-plan workspace were the most popular spaces for a few activities (i.e., administrative, focus/technical work, evaluation, and formal meeting), none of them showed the same range of popularity across activities as the aforementioned natural outdoor spaces. The park workspace did not show as much range as the other three natural outdoor spaces, but it was selected as the most popular space to exercise within, was among the three most popular spaces for three other activities, and was almost never selected as the worst space to engage in a workplace activity.

Natural outdoor spaces were consistently underrepresented in the bottom four spaces

across all workplace activities (see Table 3). Almost no participants chose natural outdoor spaces as the worst spaces for informal meetings, individual reflection, breaks, and lunches. Natural outdoor spaces were also markedly absent in the bottom four spaces for brainstorming, evaluation, and group reflection tasks. It is interesting to note that natural outdoor spaces were also underrepresented in the bottom four spaces for the administrative and focus/technical tasks, despite the fact that natural outdoor spaces were not in the top four for these tasks. These results indicate that even when natural outdoor spaces are not thought to facilitate work performance on a given activity, they are not perceived to negatively affect engagement in any activity, and are perceived as more beneficial than a number of existing workspace types.

In general, regardless of the specific workplace activity, natural outdoor spaces were overrepresented (64.75%) in the top four preferred spaces ($z = 6.73$, $p < .01$), and markedly absent (8.75%) in the bottom four spaces ($z = 3.14$, $p < .01$).

See Table 4 for the average acoustic and privacy preferences for each workplace activity. The valuing of privacy for a workplace activity tended to be accompanied by a preference for silence as well.

2.3. Discussion

The purpose of Study 1 was to determine which workspaces are perceived to facilitate performance on a variety of activities that individuals commonly engage in at work. Although general preferences for natural over constructed environments replicate previous research (Dopko et al., 2014; Hartig et al., 1996; Kaplan & Kaplan, 1989; Kaplan et al., 1972; Ulrich, 1981; Van den Berg et al., 2003), our findings also offer a more nuanced understanding by attempting to account for the social and behavioral context, as well as the type of natural space. Natural outdoor spaces were thought to benefit work performance for most, but not all,

workplace activities. Natural outdoor space preferences were found for activities like taking a break, having lunch, or exercising that can occur before, between, or after work tasks and may serve as opportune moments for restoration given the right environmental context. Natural outdoor spaces were also more likely to be chosen as ideal environments for less structured, more abstract activities such as brainstorming, reflection, and evaluation, which have been argued to be important aspects of the creative process (e.g., Funke, 2009; Lubart, 2001). This is consistent with previous research that has found that natural environments and elements are (and are thought to be) conducive to creative thinking (Atchley et al., 2012; McCoy & Evans, 2002; Shibata & Suzuki, 2004). It is only for structured and habitual workplace activities like technical/focus and administrative work that natural outdoor spaces were not more likely to be chosen as the best places to work. This is in line with some previous studies that "suggest that effects of viewing plants on task performance may be task dependent" (Shibata & Suzuki, 2004, p. 373) and less beneficial for simple, repetitious tasks (e.g., Larsen et al., 1998), and with restorative environmental design's assumption about activity cycles where restorative environments may not be optimal for activities that are more cognitively demanding (Hartig et al., 2008). Nevertheless, even for these activities, natural outdoor spaces were less likely to be selected as the worst workspaces, and one natural outdoor space was still among the three most popular spaces for administrative and individual focus/technical work (or among the four most popular spaces for group focus/technical work). Moreover, existing research suggests that performance on these types of activities would likely improve if workers are exposed to nature beforehand (e.g., Lee et al., 2015) or present in a nature-enriched workspace during the activity (Knight & Haslam, 2010; but see Larsen et al., 1998).

Our results suggest that nearby nature or natural environments incorporated within the

workplace might be perceived by many as attractive places to work on a wide range of activities. It is important to note that natural outdoor spaces were preferred for activities where privacy and silence were highly valued (e.g., lecture), as well as for activities where more openness and noise was preferred (e.g., lunch). In addition, individual green nature spaces like the dense forest, meadow, and forest amphitheatre were among the most popular workspaces for a wider range of workplace activities than any of the constructed workspaces. Thus, natural spaces might be viewed as highly flexible, multi-use spaces that are appropriate or ideal for many of the activities that knowledge workers commonly engage in. These preferences for natural spaces might translate into high space use rates, potentially fostering boosts in emotional well-being, creativity, and general cognitive performance that interaction with nature has been shown to elicit (e.g., Atchley et al., 2012; Kaplan & Berman, 2010; MacKerron & Mourato, 2013).

The results from Study 1 also suggest that integrating natural environments around or within office buildings might reduce construction and operation costs, which is in line with previous research (Hellinga & de Bruin-Hordijk, 2010; Mangone et al., 2014; Mangone & van der Linden, 2014; Mangone 2015; Romm & Browning, 1994; Terrapin Bright Green, 2012). Since a number of different activities are perceived as being optimally performed in natural outdoor spaces, not as many specialized spaces may need to be built or maintained to accommodate the preferences of knowledge workers. For instance, providing a single natural environment that allows for diverse types of individual and group activities may be a more efficient use of space than providing separate spaces for specific activities, such as having a cafeteria for lunches, a lecture hall for lectures, a lounge for informal meetings, etc. Nevertheless, as natural outdoor spaces were not universally perceived as being the best space for engaging in all activities (i.e., work tasks requiring high levels of concentration, linear

thinking, and structure), also providing access to some of the more popular constructed indoor workspaces (i.e., cellular offices, open-plan workspaces, and formal meeting rooms) might offer enough diversity to satisfy the preferences of most knowledge workers. Further research is necessary to determine the effects of not including certain space types in office environments which previous research and this study indicate are undesirable or ineffective for various workplace activities. As the diversity and quantity of available space types can be important (Duffy & Powell, 1997; Gruys, Munshi, & Dewett, 2011; Meusburger, 2009; Vink et al., 2008), investigating the effects of various workspace type combinations and quantities on worker preferences and performance is needed. Finally, the relative absence of the cave workspace in Table 2 and the varying popularity of natural outdoor space types for the different workplace activities suggest that natural workspaces should be selected with care; not all natural environments are viewed similarly when it comes to perceived work performance. In general, however, our preliminary results suggest that the integration of natural space types around or within office environments might be an effective way of promoting work satisfaction and performance among knowledge workers.

Although there are some examples of companies recognizing and capitalizing on the benefits of nature at work (e.g., Google; Peter, 2015), workplaces still tend to be relatively nature-impoverished. Our results suggest that the provision of several types of green nature spaces into office environments might be perceived as highly desirable by many knowledge workers, and might foster greater performance on a variety of workplace activities. While the potential implications of these findings are wide-ranging, they are, admittedly, mostly speculative at this point; more research is needed before more definitive conclusions can be drawn and stronger evidence-based suggestions can be offered.

3. Study 2

A second study was conducted to examine how perceptions of spatial qualities differ between the natural outdoor and constructed indoor workspaces. This allowed us to test whether the images were being perceived as intended (e.g., that natural outdoor spaces were perceived as being more natural) and elucidate potential reasons why natural outdoor spaces might have been preferred overall and for particular workplace activities.

3.1. Method

3.1.1. Participants

Thirty-three faculty members who participated in Study 1 were randomly selected to participate in Study 2. In terms of demographics, 63.6% of the sample was male (n = 21) and the average age was 42.6 years old (SD = 10.31).

3.1.2. Materials and procedure

Study 2 used the same 15 images as Study 1. Using a 7-point scale, participants rated each space on 11 different spatial qualities, including how fascinating, distracting, relaxing, informal, loud, private, bright, and open they perceived the space to be, how much they considered the space type to be an office space or a natural environment, and how much natural light (versus artificial light) they perceived the space to have. Spatial qualities were chosen based on selection reasons articulated by participants in the pilot study and Study 1, as well as by surveying existing literature for spatial qualities that might have an influence on worker performance, well-being, and space preferences (e.g., Davis et al., 2011; Hartig et al., 2003; Kaplan, 1995; Leung et al., 2012; Vischer, 2008; Wineman, 1982). In order to reduce any order effects, the images were presented in a randomized order for each participant. Average ratings for the natural outdoor spaces and average ratings for the constructed indoor workspaces were

calculated for each participant on each spatial quality. This was done so that the two categories of spaces could be compared using paired sample *t*-tests; the cave image was excluded from the analyses. Paired sample *t*-tests comparing the natural outdoor spaces to the cave image appear to support this decision as significant differences were found for almost all of the spatial qualities. Perhaps most relevant, the cave was perceived as being more of a natural environment than the constructed indoor workspaces, $t(32) = 12.40$, $p < .01$, $d = 2.72$, but less of a natural environment than the natural outdoor spaces, $t(32) = -8.92$, $p < .01$, $d = -2.48$, suggesting that it did not fit well into either category. The survey took participants approximately five to ten minutes to complete.

3.2 Results

As illustrated in Table 5, mean level differences between natural outdoor and constructed indoor workspaces on most of the items were statistically significant and large in magnitude. In particular, participants rated natural outdoor spaces as being significantly more representative of natural environments and containing significantly more natural light than constructed indoor workspaces. Natural outdoor spaces were also perceived as being significantly more fascinating, relaxing, open, bright, and informal than the constructed indoor workspaces. In contrast, the constructed indoor workspaces were rated as being significantly louder and more representative of typical office spaces than the natural outdoor spaces. Natural outdoor spaces were also rated as being less private (i.e., more public) and less distracting than the constructed indoor workspaces, but these differences did not reach traditional levels of statistical significance.

Interestingly, workspace preferences for specific workplace activities seemed to depend on more than one spatial quality. For instance, in Study 1, the dense forest, meadow, and forest amphitheatre were selected as some of the best spaces for between work task activities, such as taking a break or having lunch and for creative activities like brainstorming. However, in Study

2, we found that these natural outdoor spaces were not all rated similarly in spatial qualities such as loudness, $F(2, 64) = 13.44$, $p < .01$, $\eta_p^2 = .30$, brightness, $F(2, 64) = 108.43$, $p < .01$, $\eta_p^2 = .77$, and openness, $F(2, 64) = 96.95$, $p < .01$, $\eta_p^2 = .75$. Participants also had dissimilar perceptions of how distracting, $F(2, 64) = 5.56$, $p < .01$, $\eta_p^2 = .15$, private, $F(2, 64) = 20.87$, $p < .01$, $\eta_p^2 = .40$, and relaxing, $F(2, 64) = 6.72$, $p < .01$, $\eta_p^2 = .17$, these spaces were. Visual inspection of boxplots and Shapiro-Wilks tests suggested that there were some potential outliers and issues with non-normality in some of these tests. Nevertheless, interpretation of the results remained the same when analyses were run without the potential outliers and when nonparametric tests were used.

Additional support for workspace preferences being based on more than one spatial quality comes from examining specific workplace activities. As an example, the two most popular spaces for administrative work were the cellular office and the open-plan workspace, despite being significantly different in terms of perceived loudness, $t(32) = -7.33$, $p < .01$, $d = -1.66$, privacy, $t(32) = -7.76$, $p < .01$, $d = -1.77$, and openness, $t(32) = -9.38$, $p < .01$, $d = -1.73$. Similarly, although open, spacious settings have been shown to promote creativity, and open spaces such as the forest amphitheatre ($M = 6.15$, $SD = 0.83$) and meadow ($M = 6.88$, $SD = 0.33$) were among the most popular choices for creative activities like brainstorming, relatively enclosed workspaces, such as the formal meeting room ($M = 2.61$, $SD = 1.14$) and lounge ($M = 3.76$, $SD = 1.03$), were also commonly (albeit less frequently) chosen as the best space to engage in these kinds of activities. See Tables S1 and S2 in the Supplementary Material for descriptive statistics for each space on all of the spatial qualities, as well as inferential statistics comparing the constructed indoor workspaces to one another and the natural spaces to one another on each spatial quality.

3.3. Discussion

In general, perceptions of the spatial qualities of natural outdoor and constructed indoor workspaces were consistent with expectations. The natural outdoor spaces were rated as being highly representative of natural environments and containing high levels of natural light, while the constructed indoor workspaces were considered to be more representative of typical office space, thereby validating our image selection. As predicted by attention-restoration (Kaplan & Kaplan, 1989) and stress-reduction theories (Ulrich et al., 1991), outdoor natural spaces were seen as more fascinating and relaxing than constructed indoor workspaces.

The findings from Study 2 also suggest that workspace perceptions might be based on more than one spatial quality. Workspaces that were commonly perceived as being optimal environments to engage in specific activities frequently differed in terms of their spatial qualities. Even the popular, multi-use natural outdoor spaces identified in Study 1 were different on a variety of seemingly important qualities. Based on these findings, one might extrapolate that the influence of individual spatial qualities on knowledge workers' workspace type preferences might be more dependent on how the individual spatial qualities contribute to forming an overall environment that is conducive to engaging in specific workplace activities. This is in contrast to the notion of knowledge workers' preferences being dependent on the perceived value of one or two individual spatial qualities of a work environment. In other words, the design of effective workspaces might be more dependent on developing environments that integrate multiple spatial qualities in ways that effectively promote work activities, rather than solely focusing the design on promoting one or two spatial qualities. One might also extrapolate that many knowledge workers prefer to have access to a variety of workspace types which are comprised of different spatial qualities, when engaging in everyday workplace activities. Moreover, natural outdoor

spaces might be perceived as particularly attractive, flexible, and innovative places to engage in a variety of these workplace activities. Thus, the consideration of a variety of spatial qualities in the design and evaluation of the performance of workspace types might be important in trying to meet the needs and wants of knowledge workers.

4. General Discussion

Overall, the results of this study suggest that knowledge workers think that their performance on a variety of workplace activities might improve if they are given access to a greater diversity of workspace types than those that are typically provided in office environments. Indeed, innovative workspace types, particularly natural spaces, may be effective at maximizing performance on a variety of creative and non-creative workplace activities, as well as improving general worker satisfaction. Our findings indicate that some of the natural outdoor space types were preferred for different types of workplace activities, and were perceived differently in terms of their spatial qualities. Thus, if the predictions of the participants and previous research are accurate, provision of access to multiple types of natural spaces might lead to greater increases in worker satisfaction and performance across the diverse range of workplace activities that knowledge workers perform, compared to the provision of access to a single type of natural space or no natural spaces.

Although all of the potential implications mentioned throughout this paper are intriguing, caution should be taken when making strong conclusions from our findings as there are several limitations to the studies that we conducted. First, the actual work performance of knowledge workers was not directly measured; participants were simply asked which spaces they thought they would perform the best/worst in. These predictions may not be completely accurate and could be susceptible to forecasting errors (cf. Wilson & Gilbert, 2003). Judgments in the current

research were based solely on the limited visual information in the static images that were presented, whereas actual immersion in a natural environment is a dynamic and multi-sensory experience. Nevertheless, existing research has found that preferences for images of natural environments and preferences for the same natural environments when people are immersed within them tend to be reliably associated. (e.g., Daniel & Boster, 1976; Hammit, 1980; Shafer & Richards, 1974). This offers some support for the external validity of our methods and results Our recruitment of individuals with expertise in the physical environment and direct experience with a diversity of workspaces might have led to more accurate judgments compared to laypeople, but we unfortunately cannot test the validity of this assertion with the current data. There is evidence that people tend to underestimate the psychological benefits that nature contact can provide (Nisbet & Zelenski, 2011), although that research was limited to investigating predictions made by non-experts (i.e., undergraduate students) concerning emotional, not cognitive, functioning. Experimental and field research that measures actual work performance and satisfaction in different natural and constructed workspaces over time is needed to extend the current research and address the above concerns. This could also allow researchers to investigate how long-lasting the effects might be, whether workers become habituated to their natural surroundings, and how preferences and perceptions might shift over time.

As we noted earlier, we pilot tested the images to make sure that each image was perceived as being representative of its respective space type, and we avoided including photos with extraordinary stimuli. Participant responses, however, may have still been influenced by the idiosyncratic features of the chosen images, instead of the space types per se. For instance, a couple of the workspace images contained people within them, while the rest did not. The layout of seats and other furniture in the workspaces could have unduly influenced preferences and

perceptions as well. Finding a similar pattern of results with a different set of images would help increase confidence in the current findings. Our images of constructed indoor workspaces were also limited in that these types of spaces can still allow for exposure to nature via window views, yet none of our images included these views. Comparing outdoor natural spaces to constructed indoor workspaces with and without window views of nature would be a valuable extension of the current research. Similarly, future research that manipulates natural and constructed spaces on the indoor-outdoor dimension (e.g., a 2 x 2 design where perceptions and preferences for constructed indoor, constructed outdoor, natural indoor, and natural outdoor spaces are investigated) could help provide stronger support for not just nearby nature outside of the workplace, but for natural environments embedded within the workplace as well.

Preferences might have been different if we had not attempted to reduce concerns about comfort, technology, and accessibility when instructing participants. It is important to take this limitation into consideration when interpreting our findings, even though many of these issues can be effectively addressed through performance based design and space planning. Researchers may want to assess the prevalence and strength of these concerns among knowledge workers, as well as the role of these concerns as potential roadblocks to connecting with nature at work.

Although our repeated-measures design provided us with greater statistical power than we would have had with other possible designs, our sample size in both studies was still fairly small. Future studies should recruit larger samples. A larger sample size would increase researchers' ability to detect statistically significant differences between workspaces, if they exist, as well as increase the precision of their estimates.

Lastly, our exclusive recruitment of individuals from one university might arguably limit the generalizability of our findings to other populations. Perceptions and preferences of

workspaces for different workplace activities might vary among knowledge workers with different experiences, occupations, and needs, as well as from different educational backgrounds and cultures. It is possible, for instance, that those who are interested and study content related to human-environment interactions might differ meaningfully on psychological characteristics (e.g., nature relatedness; Nisbet, Zelenski, & Murphy, 2009) or hold disciplinary knowledge that could bias their responses in favor of natural workspaces. Nonetheless, the general preference for scenes of nature over constructed spaces that has been documented across a wide range of cultures (Ulrich, 1993), and the theoretical underpinnings of biophilic architecture (Kellert et al., 2008) hint that natural spaces might be preferred over constructed workspaces for most workplace activities, and for most knowledge workers. Future research needs to be conducted to test the veracity of this claim, as well as determine the replicability, boundary conditions, and generalizability of our results.

Despite growing evidence for the cognitive, emotional, and physical health benefits of interacting with nature, constructed indoor workspaces devoid of nature remain all-too-common. In fact, some workplaces are even removing their plants in attempts to save money (e.g., Barton, 2014). A growing body of research suggests that providing opportunities to connect with nature will often lead to happier, healthier, and more productive workers (but see Larsen et al., 1998). Our results show that knowledge workers generally perceive natural outdoor spaces to be conducive to work performance for a wide range of everyday activities. With these findings, we provide further evidence for the importance of providing access to natural environments at work. Employers, architects, and designers take heed; bringing nature to work might be a win-win.

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Table 1

Selection of Natural Outdoor Spaces as Best Workspaces

Workplace Activity	*M* % of Natural Outdoor Spaces in Top 4	*z*
Administrative	28.12%	0.26
Individual Break	72.66%	8.32**
Group Break	59.77%	5.99**
Individual Brainstorming	56.64%	5.42**
Group Brainstorming	44.92%	3.30**
Individual Focus/Technical Work	27.73%	0.19
Group Focus/Technical Work	19.92%	-1.22
Individual Reflection	57.42%	5.56**
Group Reflection	48.44%	3.94**
Individual Evaluation	53.91%	4.93**
Group Evaluation	38.28%	2.10*
Informal Meeting	51.17%	4.43**
Formal Meeting	19.14%	-1.36
Individual Lunch	72.66%	8.32**
Group Lunch	68.75%	7.61**
Lecture	41.02%	2.96**
Exercise	85.94%	11.26**

Note. Sample size was 64 across all tests. The observed mean proportions were compared to an expected proportion of .2667 associated with the null (i.e., no workspace preference) for all workplace activities except lecture and exercise. For these two activities, the observed mean proportions were compared to an expected proportion of .25 as an additional constructed workspace image (i.e., lecture hall with window) was available for participants to choose from.
*$p < .05$. **$p < .01$.

Table 2

Perceived Best Workspace for Each Workplace Activity (% of Participants Who Placed Workspace in Top Spot)

Workplace Activity	Most Popular	2nd Most Popular	3rd Most Popular
Administrative	Cellular Office (35.9%)	Open-plan Workspace (15.6%)	Meadow (14.1%)
Individual Break	Forest Amphitheatre (34.4%)	Meadow (26.6%)	Dense Forest (20.3%)
Group Break	Meadow & Forest Amphitheatre (28.1%)	Dense Forest (15.6%)	Cave (7.8%)
Individual Brainstorming	Forest Amphitheatre (23.4%)	Meadow (18.8%)	Dense Forest (15.6%)
Group Brainstorming	Forest Amphitheatre (20.3%)	Meadow & Formal Meeting (17.2%)	Lounge (9.4%)
Individual Focus/ Technical Work	Cellular Office (43.8%)	Dense Forest (14.1%)	Informal Private Meeting (10.9%)
Group Focus/ Technical Work	Open-plan Workspace (28.1%)	Formal Meeting (18.8%)	Lab (14.1%)
Individual Reflection	Meadow (23.4%)	Forest Amphitheatre (21.9%)	Dense Forest (18.8%)
Group Reflection	Meadow (17.2%)	Forest Amphitheatre (15.6%)	Dense Forest & Park (14.1%)
Individual Evaluation	Cellular Office (21.9%)	Meadow (20.3%)	Dense Forest (17.2%)
Group Evaluation	Formal Meeting (28.1%)	Meadow (17.2%)	Lounge & Dense Forest (9.4%)

Informal Meeting	Meadow (21.9%)	Dense Forest & Lounge (20.3%)	Park (9.4%)
Formal Meeting	Formal Meeting (59.4%)	Cellular Office (10.9%)	Dense Forest (9.4%)
Individual Lunch	Meadow (32.8%)	Dense Forest (25%)	Forest Amphitheatre (18.8%)
Group Lunch	Meadow (35.9%)	Dense Forest (26.6%)	Forest Amphitheatre (15.6%)
Lecture	Forest Amphitheatre, Lecture Hall, & Lecture Hall with Window (29.7%)	Meadow, Dense Forest, & Cave (3.1%)	Park (1.6%)
Exercise	Park (48.4%)	Meadow & Forest Amphitheatre (20.3%)	Gym & Dense Forest (4.7%)

Note. Workspaces are presented in the same cell when the percentage of participants who selected the workspace as the best was the same as another workspace.

Table 3

Selection of Natural Outdoor Spaces as Worst Workspaces

Workplace Activity	*M* % of Natural Outdoor Spaces in Bottom 4	*z*
Administrative	15.63%	-2.00*
Individual Break	0.39%	-4.75**
Group Break	0.39%	-4.75**
Individual Brainstorming	3.13%	-4.26**
Group Brainstorming	7.42%	-3.48**
Individual Focus/Technical Work	8.20%	-3.34**
Group Focus/Technical Work	10.94%	-2.85**
Individual Reflection	1.56%	-4.54**
Group Reflection	6.25%	-3.69**
Individual Evaluation	3.17%	-4.22**
Group Evaluation	7.81%	-3.41**
Informal Meeting	1.17%	-4.61**
Formal Meeting	16.80%	-1.79
Individual Lunch	0.78%	-4.68**
Group Lunch	1.17%	-4.61**

Note. The sample size was 64 across all tests, except for individual evaluation which had a sample size of 63. The observed mean proportions were compared to an expected proportion of .2667 associated with the null (i.e., no workspace preference). Participants were not asked to select the bottom four spaces for the lecture and exercise activities.
*$p < .05$. **$p < .01$.

Table 4

Acoustic and Privacy Preferences for Each Workplace Activity

Workplace Activity	Acoustic Preference *M* (*SD*)	Privacy Preference *M* (*SD*)
Administrative	2.42 (1.21)	2.84 (1.42)
Individual Break	3.19 (1.32)	3.59 (1.54)
Group Break	3.59 (1.20)	4.09 (1.59)
Individual Brainstorming	1.50 (0.76)	1.59 (0.83)
Group Brainstorming	1.97 (1.07)	1.94 (1.25)
Individual Focus/Technical Work	1.39 (0.55)	1.33 (0.51)
Group Focus/Technical Work	1.72 (0.72)	1.71 (0.92)
Individual Reflection	1.63 (0.77)	1.63 (0.88)
Group Reflection	1.92 (0.84)	1.92 (1.07)
Individual Evaluation	1.61 (0.77)	1.63 (0.85)
Group Evaluation	1.84 (0.88)	1.81 (0.97)
Informal Meeting	2.94 (1.07)	3.11 (1.25)
Formal Meeting	1.77 (0.83)	1.56 (1.01)
Individual Lunch	3.06 (1.22)	3.28 (1.52)
Group Lunch	3.25 (1.31)	3.83 (1.65)
Lecture	1.38 (0.60)	1.88 (1.18)
Exercise	3.58 (1.57)	3.20 (1.71)

Note. Preferences were rated on a 7-point scale, with lower scores indicating a greater preference for silence or privacy, and higher scores indicating a greater preference for noise or openness/publicness.

Table 5

Spatial Quality Ratings of Natural Outdoor and Constructed Indoor Workspaces

	Natural Outdoor Spaces	Constructed Indoor Workspaces		
	M (SD)	*M* (SD)	*t*	*d*
Bright	5.45 (0.70)	4.19 (0.60)	7.61**	1.93
Distracting	3.53 (1.18)	3.64 (0.57)	-0.47	-0.12
Fascinating	5.58 (1.00)	2.92 (0.68)	15.13**	3.05
Informal	6.20 (0.71)	3.82 (0.51)	17.06**	3.82
Loud	2.85 (1.09)	3.66 (0.55)	-3.67**	-0.96
Natural Light	6.77 (0.43)	2.94 (0.46)	38.97**	8.70
Natural Environment	6.39 (0.45)	1.36 (0.53)	50.86**	10.26
Open	5.92 (0.77)	3.54 (0.75)	13.99**	3.12
Not Typical Office Space	6.17 (0.92)	3.33 (0.67)	12.85**	3.54
Public	4.59 (1.19)	4.12 (0.57)	1.89	0.51
Relaxing	6.29 (0.53)	3.45 (0.60)	25.54**	4.99

Note. Degrees of freedom for all paired samples t-tests was 32. Shapiro-Wilk tests were nonsignificant for all spatial quality items ($p > .05$), indicating that there were no major violations of the nearly normal condition. Although boxplots of the difference scores pointed to potential outliers for some of the items (i.e., distracting, loud, natural, and public), excluding these individuals did not meaningfully change the results.
**$p < .01$.

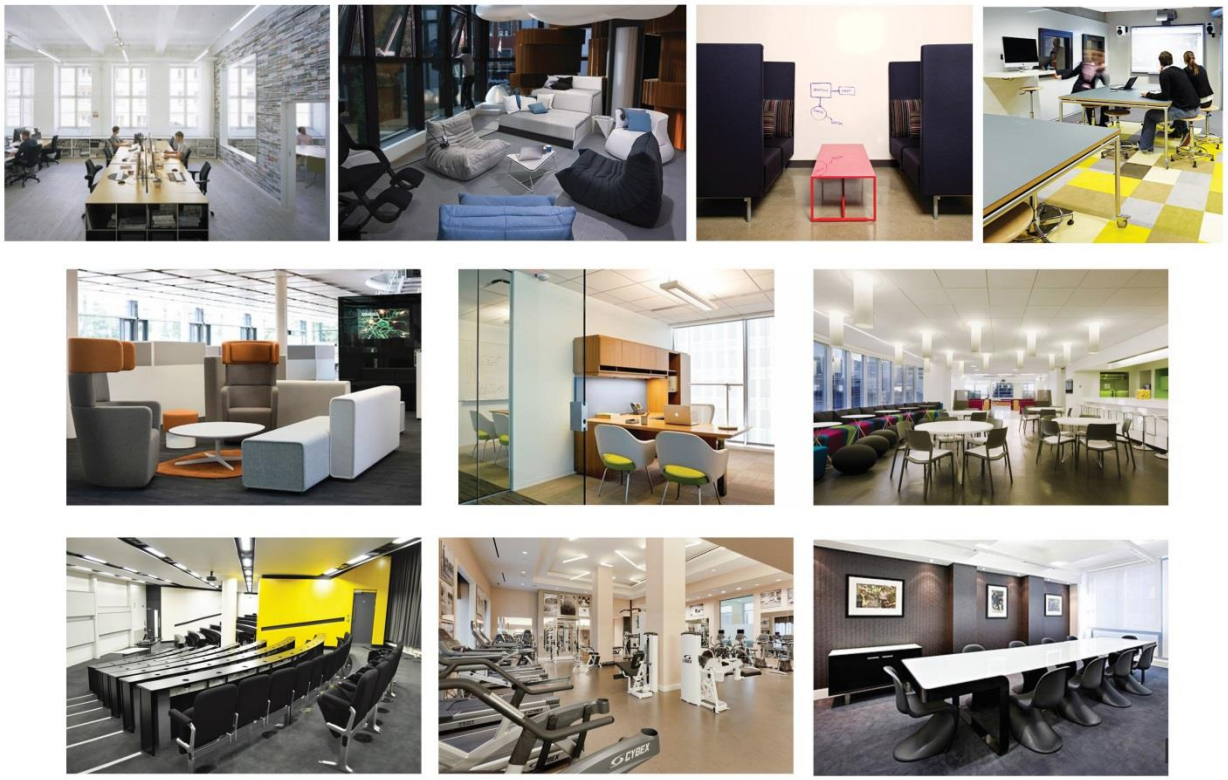

Fig. 1. From left to right, top to bottom: open-plan workspace, lounge, informal private meeting, lab, informal public meeting, cellular office, cafeteria, lecture hall, gym, and formal meeting.

Fig. 2. From left to right, top to bottom: forest amphitheatre, meadow, dense forest, park, and cave.

Table S1

Repeated Measures Analysis of Variance Comparing Spatial Quality Ratings for Natural Spaces

	Forest amphitheater	Meadow	Dense forest	Park	Cave		
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*	η_p^2
Bright	5.70_{a} (0.92)	6.76_{b} (0.50)	4.42_{c} (0.97)	4.91_{d} (1.04)	1.88_{e} (0.65)	233.06**	.879
Distracting	3.94_{a} (1.41)	3.42_{ab} (1.87)	3.03_{b} (1.26)	3.73_{a} (1.28)	3.91_{a} (1.55)	3.45*	.097
Fascinating	5.82_{a} (1.07)	5.85_{ab} (1.44)	5.42_{bc} (1.17)	5.21_{c} (1.17)	4.18_{d} (1.85)	12.48**	.280
Informal	6.15_{a} (0.97)	6.27_{a} (0.98)	6.18_{a} (0.98)	6.21_{a} (0.89)	5.27_{b} (1.28)	8.24**	.205
Loud	3.39_{a} (1.30)	2.55_{b} (1.23)	2.61_{b} (1.12)	2.85_{b} (1.30)	4.67_{c} (1.24)	24.03**	.429
Natural Light	6.79_{a} (0.42)	7.00_{b} (0.00)	6.61_{c} (0.75)	6.70_{ac} (0.59)	1.27_{d} (0.67)	1010.38**	.969
Natural Environment	5.70_{a} (0.95)	6.88_{b} (0.42)	6.52_{c} (0.62)	6.48_{c} (0.62)	4.12_{d} (1.29)	58.32**	.646
Open	6.15_{a} (0.83)	6.88_{b} (0.33)	4.76_{c} (1.28)	5.91_{a} (1.04)	2.27_{d} (1.15)	149.61**	.824

Not Typical Office Space	6.55_{a} (0.62)	6.03_{bcd} (1.24)	5.79_{bd} (1.39)	6.30_{ac} (0.98)	5.42_{d} (1.37)	7.66**	.193
Public	5.52_{a} (1.35)	4.00_{b} (1.73)	3.85_{b} (1.37)	5.00_{c} (1.44)	4.97_{c} (0.98)	13.68**	.300
Relaxing	6.27_{a} (0.67)	6.64_{b} (0.60)	6.18_{a} (0.81)	6.06_{a} (0.97)	4.45_{c} (1.46)	33.88**	.514

Note. Within a row, means not sharing a subscript differ at $p < .05$. Degrees of freedom were 4, 128 across the omnibus analysis of variance tests. The sphericity assumption was commonly violated, but results were similar when the Greenhouse-Geisser correction was used.
* $p < .05$. ** $p < .01$.

Table S2

Repeated Measures Analysis of Variance Comparing Spatial Quality Ratings for Constructed Indoor Workspaces

	Open-plan 1	Lounge 2	Informal private meeting 3	Lab 4	Informal public meeting 5	Cellular office 6	Cafeteria 7	Lecture hall 8	Gym 9	Formal meeting 10		
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*	η_p^2
Bright	5.48_{a} (0.80)	3.24_{b} (0.83)	3.94_{cd} (0.86)	3.85_{ce} (1.37)	4.30_{f} (0.92)	5.36_{a} (0.90)	4.33_{efg} (0.89)	3.24_{b} (1.37)	4.30_{dfh} (1.24)	3.88_{cgh} (1.22)	22.26**	.410
Distracting	3.70_{a} (1.10)	3.94_{a} (0.93)	3.09_{b} (1.26)	2.97_{bc} (1.67)	3.97_{a} (1.19)	2.48_{cd} (1.35)	5.45_{e} (1.15)	2.36_{d} (1.32)	5.94_{f} (1.30)	2.48_{cd} (1.28)	35.39**	.525
Fascinating	4.24_{a} (1.54)	3.94_{a} (1.20)	2.85_{bcd} (1.12)	2.18_{ef} (1.24)	2.91_{bd} (1.18)	2.79_{bde} (1.45)	3.24_{d} (1.39)	2.42_{beg} (1.35)	2.58_{beg} (1.48)	2.06_{fg} (1.06)	11.95**	.272
Informal	3.21_{ab} (1.22)	5.45_{c} (1.15)	4.97_{d} (1.26)	3.52_{a} (1.33)	4.24_{e} (1.32)	2.79_{b} (1.11)	4.73_{de} (1.15)	1.85_{f} (1.18)	5.97_{c} (1.38)	1.52_{f} (0.67)	57.71**	.643
Loud	3.91_{a} (1.28)	3.61_{ab} (0.93)	3.24_{b} (1.06)	3.33_{bc} (1.43)	3.88_{ac} (0.96)	2.09_{d} (0.84)	5.94_{e} (0.79)	2.27_{d} (0.94)	6.24_{e} (0.83)	2.12_{d} (0.89)	86.66**	.730
Natural Light	4.88_{a} (0.89)	3.64_{b} (1.27)	2.67_{c} (1.16)	1.73_{d} (1.04)	3.39_{b} (0.79)	4.45_{a} (1.12)	2.82_{c} (0.81)	1.03_{e} (0.17)	1.76_{d} (0.75)	3.00_{c} (0.87)	66.30**	.674
Natural Environment	1.64_{ab} (0.96)	1.76_{a} (0.94)	1.58_{ab} (1.06)	1.15_{cd} (0.44)	1.42_{b} (0.66)	1.45_{abc} (1.00)	1.27_{bce} (0.63)	1.06_{de} (0.24)	1.09_{d} (0.38)	1.18_{cd} (0.47)	6.86**	.177
Open	4.82_{ab} (1.16)	3.76_{c} (1.03)	3.00_{d} (1.12)	2.21_{e} (1.17)	3.61_{c} (1.00)	2.82_{d} (1.16)	4.94_{a} (1.35)	3.24_{cd} (1.73)	4.39_{b} (1.68)	2.61_{de} (1.14)	24.66**	.435
Not Typical Office Space	1.91_{ab} (1.10)	4.48_{c} (1.28)	4.00_{d} (1.46)	2.33_{b} (1.45)	3.55_{e} (1.42)	1.64_{a} (1.08)	4.48_{cd} (1.72)	2.58_{b} (1.79)	6.64_{f} (0.82)	1.67_{a} (1.05)	56.39**	.638

Public	4.24_{a} (1.32)	3.85_{ab} (1.35)	3.52_{b} (1.20)	3.24_{b} (1.28)	4.06_{a} (1.20)	2.15_{c} (1.12)	6.33_{d} (0.74)	5.00_{e} (1.70)	6.42_{d} (0.61)	2.39_{c} (1.22)	55.49**	.634
Relaxing	3.06_{a} (1.20)	5.30_{b} (0.92)	4.18_{c} (1.36)	2.15_{d} (1.09)	4.21_{ce} (0.96)	3.48_{ae} (1.58)	3.76_{ac} (1.58)	2.24_{d} (1.32)	3.94_{ce} (2.02)	2.18_{d} (1.04)	22.24**	.410

Note. Within a row, means not sharing a subscript differ at $p < .05$. Degrees of freedom were 9, 288 across the omnibus analysis of variance tests. The sphericity assumption was commonly violated, but results were similar when the Greenhouse-Geisser correction was used.
** $p < .01$.