Neural Correlates of Nature Stimuli: An *f*MRI Study

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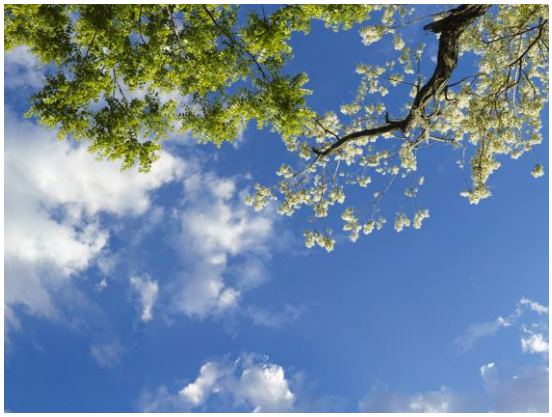

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Sky Factory

I. An Introduction: Context & History

While nature imagery has been studied extensively in healthcare environments and is recognized for its ability to elicit a positive distraction in captive populations, its therapeutic role has been limited to its representational or symbolic value.

In the last decade and a half Sky Factory, a fine art and digital technology design studio has advanced the application of compositional principles that endow nature imagery with an illusory or multisensory quality. It was the designer's contention that the properties of illusory images could generate a deeper *Relaxation Response* in the observer than has been documented employing standard representational imagery.

After over a decade of field-tested installations, the notion of using *f*MRI imaging technology suggested a unique way to validate the longstanding design premise behind the studio's photographic *Open Sky Compositions*. This artistic framework captures multiple elements—skies and vegetation—and, using compositional principles that have been used by artists since the Renaissance, also scales and carefully composes its sky photography to generate a more neurologically complex visual/sensory stimulus, which it believes facilitates biophilic engagement—the same experience of peace and calm that we associate with exposure to deep blue open skies in undisturbed nature.

Over the years, the only evidence of this psycho physiological phenomenon was based on the testimony of patients and others who reported experiencing a palpable feeling of openness and expansion that went beyond what is experienced with decorative nature imagery in healthcare settings.

Many observers reported transformative feelings of deep peacefulness or meditative-like states when in the presence of an *Open Sky Compositions*, which the designer came to understand were effected by the compositional elements present in these multisensory images.

Despite this feedback, personal experiences are by nature subjective and there was little evidence detailing the neurological correlates of these experiences.

This study was designed to understand and verify the cognitive mechanics involved in the perception of sky imagery designed as an environmental/architectural illusion—not designed to distract attention—but for cognitive engagement and healing.

While the designer advanced the hypothesis in this study, the design studio had no input on research design or data analysis. The study was subjected to the oversight of one or more institutional review boards (IRB) to ensure scientific merit and robustness.

II. **Project Description**

The objective of the study was to explore brain activation patterns in healthy adults when viewing specifically designed images of the sky (images used to create a more complex visual phenomenon—illusory views of open space) as compared to other types of images, including nature images.

The study was designed to identify areas of the brain uniquely activated by photographic sky compositions specifically designed to evoke a familiar spatial reference frame based on a universal multisensory experience (the experience of looking up at the sky from a secure vantage point under foliage) as compared to other general positive, negative, and neutral images. These specifically designed *Open Sky Compositions* represent the central visual component that powers what the design studio calls *illusions of nature* (simulated views to open sky staged to look like real skylights).

Prior to this study, there was no conclusive evidence that verified the experience of patients who reported a sensation of expansion when viewing specifically designed sky imagery.

A substantial body of research has used behavioral and physiological indicators to measure the positive impact of nature exposure on health and well-being. However, the exact neural mechanism underlying these positive influences have so far eluded environmental design researchers and practitioners. Understanding these mechanisms is of both scholarly and professional importance.

From a scholarly perspective, the use of neuroscience theories and techniques offers the expansion of environmental design into empirically driven objective studies that will supplement the (mostly) subjective methods used currently. It creates an additional avenue for triangulation within environmental design research, and greater granularity in understanding the associations between the built environment and its occupants.

This methodology also sheds light on the neuroarchitecture of perception, confirming that an alternate experience of interior space is possible when imagery is designed to evoke a familiar spatial reference—spatial relationships that our memory readily recognizes—over ad hoc representational scenes.

From a design practice perspective, since all design disciplines essentially manipulate visual stimuli, understanding neural responses to positive and negative environmental stimuli (and the relative magnitudes associated with different design options including those involving nature scenes) could eventually enhance evidence-based design decision making.

Research Question

Given the large body of behavioral and physiological evidence suggesting positive associations between exposure to nature and healthcare outcomes, a central research question remained. Are there unique neural activations associated with exposure to the sky? More specifically, does exposure to photographic sky compositions activate brain regions that are different from other types of visual images?

Studies have shown that most forms of nature exposure have a positive influence on patients. The positive effects include reductions in stress, anxiety, pain, and fear, thereby leading to empirically validated reductions in length of stay, use of analgesic medications, and other positive patient outcomes. The academic community has explained this benefit in terms of various theoretical frameworks, including Restoration theory, Biophilic/Evolutionary theory, and Emotional Congruence theory.

The objective of the investigation was to shed light on the neuroarchitecture of illusory nature stimuli.

Research Value

The possibility that nature stimulus can be designed to evoke a multisensory illusion (a visual and spatial experience) has noteworthy implications. Images perceived as biophilic illusions can reasonably be expected to hold more robust restorative benefits than standard representational images simply on account of their deeper impact on our organs of perception. This constitutes a stimulating proposition with considerable design impact for health and sustainability.

At this time, evidence-based design in healthcare settings does not distinguish between nature image types. A nature photograph, regardless of scale, perspective, or physical dimensions is considered just as therapeutic as a painting depicting a nature scene. Our findings indicate that a new typology of nature stimulus—sky images specifically designed to tap unique areas of the brain associated with spatial cognition—may merit discrete consideration as they alter the observer's experience of perceived open interior space.

III. Abstract

Background
The positive impact of nature images on health outcomes has traditionally been measured using behavioral and physiological indicators. However, there is a lack of understanding of the underlying neural mechanism that explains this positive influence.

Objective
Examine whether there are unique patterns of brain activation associated with exposure to photographic sky compositions (representing nature stimulus) as compared with other positive, negative and neutral images.

Method
A combination of behavioral responses and functional Magnetic Resonance Imaging (fMRI) technology was used to address the research questions. Ten participants belonging to five age groups were subjected to short (25 seconds) exposures of 32 images while their brain activation was monitored via the BOLD response. In a separate run, participants were subjected to extended exposures (12 minutes) of a sky composition and an image of a traditional ceiling.

Results
The results show that the activation patterns produced by sky compositions and positive images were quite similar as compared to negative or neutral images. However, sky compositions also produced some unique areas of activation, including those associated with spatial cognition, the expanse of space, circadian rhythm and perceived motion. In the extended exposure condition, sky compositions tended to uniquely activate regions associated with dreaming, while traditional ceiling image uniquely activated regions that are related to face processing and potentially, visual hallucinations.

Conclusion
Nature stimulus with a combination of vegetation and sky may produce unique beneficial effects, not present in general positive stimulus.

Keywords**:** *f*MRI, neuroscience, nature stimuli, positive distraction, physical environment

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