

# Effects of dynamic light patterns with natural and non-natural temporal composition on reported stress recovery, fascination, and association with nature

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## EFFECTS OF DYNAMIC LIGHT PATTERNS WITH NATURAL AND NON-NATURAL TEMPORAL COMPOSITION ON REPORTED STRESS RECOVERY, FASCINATION, AND ASSOCIATION WITH NATURE

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### Abstract

#### 1. Motivation, specific objective

The temporal variability of daylight is consistently mentioned as one of its unique characteristics that could explain our strong preference towards daylight compared to electric light sources. Nevertheless, little is known about people's responses to short-term temporal changes in daylight conditions, and particularly to those that are momentary and unpredictable, such as a breeze creating dynamic dappled light patterns (i.e., sunlight filtered through a tree canopy). Results from a recent online study comparing subjective responses towards static and dynamic dappled light imagery showed that the dynamic dappled light was more preferred and rated as more fascinating and more strongly associated with nature compared to static dappled light. This association of a stimulus with nature appears to be central in our experience and to have beneficial effects: exposure to both nature and to elements that imitate nature (such as using natural imagery in projections or wallpapers) has been shown to be preferred and to help in recovery from and resilience towards stress and fatigue. As a result, there is a growing interest in translating natural elements to interventions that could induce these beneficial effects of nature indoors, but the role of lighting as such an intervention has been largely overlooked.

This study investigates the potential of dynamic lighting projections for stress recovery in a laboratory experiment simulating a single-person office. Building on the knowledge gap regarding the momentary temporal variability in daylight and the promising findings about dynamic dappled light, this study focuses on effects of natural light dynamics per se, i.e., of dynamic light patterns that follow the temporal composition of dappled light compared to a non-natural temporal composition, and that are otherwise void of naturalness cues, such as shape or colour.

#### 2. Methods

A single factor between-subjects experimental design was used to investigate the effects of temporal composition of projected light patterns on reported recovery from stress and on the experience of projected light. The between-subjects factor was the projected light, with three levels: a dynamic condition with a temporal composition of light patterns derived from dynamic dappled light (natural movement), a dynamic condition with a non-natural temporal composition of light (non-natural movement), and a static condition using a single frame from the natural movement condition (control). The natural movement condition was created by deriving the position, size, and movement of sunlight patches using MATLAB from a video of dynamic dappled light. In each video frame, each sunlight patch was translated to a circle with the same area and positioned at the geometric centre of the corresponding sunlight patch, resulting in a five-minute video with black background and white circles that changed size and position according to the original dappled light video. The non-natural movement condition was created by manipulating the position and size of each circle to deviate from the movement of the corresponding sunlight patch. The position of each circle between two consecutive frames was randomized while maintaining the same Euclidian distance, and its size was ordered to change from small to large. The mean luminance was similar between the dynamic conditions, and the mean size, speed, and number of circles remained constant. The conditions were

projected to the office wall and were adjusted so that only the white circles (and not the background) were visible.

The Mannheim Multicomponent Stress Test (MMST) was employed to increase participants' stress levels during the experiment and allow the investigation of stress recovery effects. MMST includes a cognitive stressor (a modified computer version of the Paced Auditory Serial Addition Task (PASAT)), an emotional stressor (images from the International Affective Picture System inducing negative valence), a motivational stressor (expected loss of compensation based on PASAT performance), and an acoustic stressor (white noise gradually increasing from 60 to 78 decibel).

Experimental sessions lasted 30 minutes and 67 participants (29 males, 36 females, 2 non-binary;  $M_{\text{age}} = 24$ ,  $SD_{\text{age}} = 6.13$ ) took part. After baseline measurements and conducting the MMST for five minutes, participants were exposed to one of the conditions (block randomized) during a five-minute recovery period. In this paper we focus on subjective measures of stress, which were asked immediately before (pre-stressor) and immediately after (post-stressor) the stressor, as well as after the recovery period (post-recovery), and included the Tense Arousal factor from the Activation-Deactivation Adjective Check List and a Visual Analogue Scale (VAS). After the recovery period, participants were asked to evaluate the projected lighting, and in this paper we examine how fascinating, stressful, and associated with nature the lighting was perceived (rated from 0, not at all, to 10, very).

### **3. Results**

Analyses were parametric or non-parametric following data normality. A Wilcoxon signed-ranks test between the pre- and post-stressor ratings showed that the stressor was effective for tense arousal and VAS. However, a one-way ANCOVA with post-stressor ratings as a covariate showed no influence of condition on post-recovery stress for either tense arousal or VAS. Contrary to our expectations, a Kruskal-Wallis analysis also showed no effect of condition on association with nature, indicating that the lighting condition that imitated dappled light movement was not perceived as more natural than the "non-natural movement" condition. On the other hand, a one-way ANOVA did show that condition significantly influenced fascination ratings, with post-hoc pairwise comparisons showing lower fascination for the static compared to both natural and non-natural movement conditions, and no differences between them. Moreover, Kruskal-Wallis analyses showed that the two dynamic lighting conditions were perceived as more stressful than the static condition, with no differences between the natural and non-natural movement conditions.

### **4. Conclusions**

This study investigates –to our knowledge, for the first time— experience and stress recovery stress using light stimuli with natural and non-natural temporal compositions. Results show that both dynamic lighting conditions were perceived as more fascinating but also more stressful than the static condition, and that the natural temporal composition characteristics employed in this study were not sufficient to be recognized as being strongly associated with nature.