Fatigue-Recovering Effect of a House Designed With Open Space

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Context: Exposure to a natural environment has been reported to be associated with positive effects on mental well-being. However, no report has examined the effects of a house designed with an open space connected to nature on recovery from fatigue.

Objective: The purpose of this study was to examine the effects of such an open space on recovery from mental fatigue.

Design: Placebo-controlled, crossover design.

Setting: Participants were randomized into open (connected to nature) and closed (not connected to nature) conditions.

Participants: Sixteen healthy female volunteers were enrolled.

Intervention: After a 30-minute fatigue-inducing mental task, participants moved to an open or closed recovery room for 30 minutes.

Main Outcome Measures: As fatigue-evaluating mental tasks, participants performed advanced trail making tests for 20 minutes. They were asked to rate their levels of fatigue, relaxation, comfort, and healing on a visual analogue scale from 0 (minimum) to 100 (maximum) to evaluate their subjective mental. They also underwent accelerated plethysmography.

Results: After the recovery session, lower total error counts of a cognitive test, greater levels of subjective relaxation, comfort, and healing, and lower levels of waveform index-1 assessed via accelerated plethysmography were observed in participants exposed to the open condition compared with the closed condition. These results provide evidence that the use of a house designed with an open space connected to nature during the recovery session improved cognitive function and subjective mental states. Hence, open space was effective for helping recovery from mental fatigue.

Key words: Cognitive function, fatigue, house, open space, recovery

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INTRODUCTION

Mental fatigue is defined as a psychobiological state caused by prolonged periods of demanding cognitive activity.[1] Mental fatigue is manifested as a reduced efficiency of mental workload[2] and has become one of the most significant causes of accidents in modern society.[3,4] Therefore, it is necessary to develop effective strategies to recover from mental fatigue.

Positive effects on mental well-being have been reported with exposure to a natural environment.[5,6] Even exposure to views of nature can improve well-being by relieving stress and mental fatigue.[7] The natural environment includes many types of green open spaces, such as wildlife reserves, wilderness areas, woodlands, open countryside, country parks, and urban parks.[8] However, in our modern society, it is often difficult to spend time in these areas. Recently, a new type of house has been developed; this house is designed with an open space connected to nature (Be Sai + e; Sekisui House, Ltd, Osaka, Japan). The specific design of this house allows one to easily spend a long time exposed to the natural environment, which may promote recovery from mental fatigue.[9]

The aim of this study was to test the effects of a house designed with an open space that connected to nature on recovery from mental fatigue using recently established fatigue-inducing and evaluation methods.[10,11] After a mental fatigue-inducing task, participants spent time in a house with or without an open space connected to nature. We measured mental task performance, various subjective sensations, and physiological variables to evaluate the effects of spending timing in an open space connected to nature on recovering from mental fatigue.

METHODS

Participants

Sixteen healthy female volunteers (median, 43.5 years; interquartile range, 39.0-50.0 [years of age]) were enrolled in this randomized, placebo-controlled, crossover experiment (closed and open conditions). Current smokers, individuals with a history of medical illness, taking chronic medication, or supplemental vitamins were excluded. The study protocol was approved by the Ethics Committee of Osaka City University, all participants provided written informed consent for participation in the study, and this study was done in accordance with the appropriate institutional review body and carried out with the ethical standards set forth in the Helsinki Declaration of 1975.

Experimental Design

After enrollment, participants were randomly assigned to two groups in a single-blind, crossover fashion to perform fatigue-

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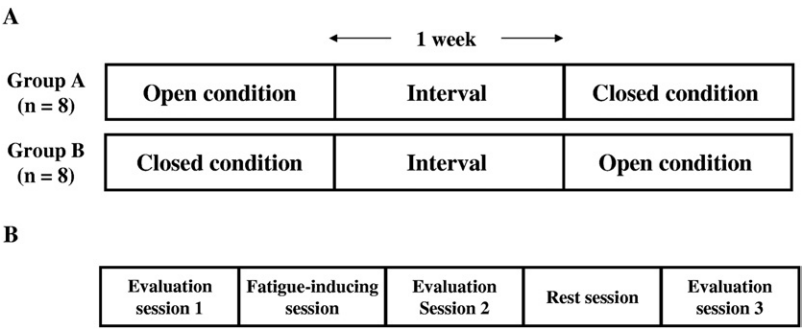

Figure 1. Experimental design (A) and procedure of experimental sessions (B). Participants were randomized to Group A or Group B. Before and 1 and 4 weeks after the start of sample intake, experiments (shown as arrows) were conducted. On each experimental day, participants performed fatigue-inducing and rest sessions, and just before and after each session, evaluation sessions were performed.

inducing and recovery sessions (Figure 1). As a fatigue-inducing mental task, they performed a "two-back" test[12] for 30 minutes,[13] and as fatigue-evaluating mental tasks, they performed advanced trail-making tests (ATMTs)[14] for 20 minutes just before and after the fatigue-inducing session. They were asked to rate their levels of fatigue, relaxation, comfort, and healing on a visual analogue scale (VAS) before and after the fatigue-inducing task. They also underwent accelerated plethysmography (APG) before and after the fatigue-inducing task. Then, they moved to a recovery room. During the recovery session, they sat on a floor quietly for 30 minutes in a room of a house designed either with an open space connected to nature (Figure 2; open condition) or without the open space (closed condition). The house for the open condition was designed with an open space connected to nature (Be Sai + e; Sekisui House, Ltd). The participants sat inside the room near the windows connected to open space with the windows open. The specific design of this house allowed them to easily spend a long time exposed to the natural environment, in which they were exposed to views, sounds, and odors of nature, and thus felt nature. As for the closed condition, the participants sat inside a room near the windows unconnected to open space with the windows closed. The house for the closed condition did not allow them to spend time exposed to the natural environment, in which they were exposed to views, sounds, and odors of nature, and thus felt nature. After the recovery session, they were again subjected to the evaluation with ATMTs, VAS, and APG. The study was conducted in a quiet temperature- and humidity-controlled environment, and the temperature and humidity were similar between the closed and open conditions. For 1 day before each visit, participants refrained from intense mental and physical activity, consumed a normal diet and beverages, and maintained normal sleeping hours. The time interval between each experiment was 1 week.

Fatigue-Inducing Task

As a fatigue-inducing task, participants performed a "two-back: test for 30 minutes, that is, either of four types of letters was continually presented on a display of a personal computer every 3 seconds. Participants had to judge whether the target letter presented at the center of the screen was the same as the one that had appeared two presentations before. If it was, they were to click the right mouse button with their right middle finger; if it was not, they were to click the left mouse button. They were instructed to perform the task trials as quickly and as correctly as possible. The result of the two-back trial—correct response or error—was continually presented on the display of the personal computer.

Fatigue-Evaluating Tasks

In fatigue-evaluating task sessions, participants performed ATMTs for 20 minutes.[13] ATMT was a self-paced mental task, composed of three types of subtasks; task A, B, and C. Participants were required to perform three types of subtask repeatedly during fatigue evaluation task session. In this test, 25 black circles with a diameter of 10 mm were randomly positioned on the white background of a laptop display. These circles were numbered from 1 to 25 in white letters of the size was 5 mm × 5 mm. Participants were required to click these circles using a computer mouse in sequence, starting with circle number 1. When the participants clicked the 25th target, the subtask of ATMT was considered completed and next subtask of ATMT was started. In ATMT task A, when participants clicked a target circle, it re-

Figure 2. Photograph of the house designed with an open space connected to nature.