Multisensory design of pocket gardens for reducing stress and improving well-being, performance and satisfaction

Noemi Bitterman\textsuperscript{a}\textsuperscript{*}, Ella Simonov\textsuperscript{a}

\textsuperscript{a}Industrial design, Faculty of Architecture and Town Planning, Technion, Haifa 32000, Israel

*Corresponding author e-mail: noemib@technion.ac.il

Abstract: Small (pocket) gardens could benefit persons living and working in modern cities. Yet, the landscape elements specifically responsible for such have not been scientifically defined. We examined isolated effects of specific landscape elements: sound, smell, ground cover, color of blossoms and bench texture; for relaxation, wellness and functionality. An interactive pictorial and vocal internet questionnaire revealed significant preference for birds chirping and fountains, and for the smell of herbal tea mix (N=219). These elements were checked at a visualization lab (a 3-D immersive theatre). Stress was induced by the PASAT test during exposure to 3D pocket garden views, with smell or sound in random order. Functional, physiological (skin sweat and pulse) and subjective measures were assessed (N=20). Although no significant differences were found in physiological and functional measures, our experimental setup appears a promising and innovative approach for defining environmental elements for relaxation and wellness promotion of urban gardens.

Keywords: Design for wellness, Multisensory design, Stress reducing environment, Soundscape, Urban gardens

1. Introduction

Since the early ages, nature, flora, sunlight and fresh air have been perceived as essential elements of human life, and as healing forces in reducing stress and in easing coping with day-to-day life difficulties (Ulrich et al, 1991). In our modern way of living, with long hours of stressful work, novel technologies and virtual social networks, we find ourselves locked up behind walls; replacing fresh air with air conditioning, and greenery with artefacts. Moreover, rising land prices and increasing urbanism threaten the existence of "natural" landscapes, parks and gardens within our cities. Yet, awareness has recently grown to the beneficial effects of nature for reducing stress and improving...
peoples’ satisfaction and wellness. In this context, small gardens (pocket gardens), within urban space and in workplaces, factories, public institutions and residential areas have become a developing field. This poses a challenge and opportunity for making nature more accessible and a means of overcoming density, lack of open spaces and a stressful environment.

A number of pioneering studies on the healing and calming effects of nature have been published; among the most known are by Ulrich et al (1984, 1991), Marcus and Barnes (1995, 1999), and Marcus and Francis (1997). In the highly-cited work by Ulrich (1984), even a natural scene out the window was shown to improve recovery from surgery (Ulrich, 1984). More recent work further supports the notion that urban green spaces may promote public health, quality of life and satisfaction in the workspace (Dravigne et al., 2008; Grahn and Stigsdotter, 2003; Stigsdotter, et al., 2010; Lohr, Pearson-Mims and Goodwin, 1996). This calls for increased awareness among municipalities and town planners for green spaces to be incorporated into urban space, not only as elements of aesthetics, beauty and landscape but also as elements for reducing stress and promoting health, with social and economic implications (Stigsdotter, et al., 2010).

Despite the growing awareness, the specific landscape elements that may contribute to feelings of wellness have not been defined (Nordh et al., 2009; Yang and Kang, 2005). This paper presents a pilot study, in which the isolated effects of specific landscape elements were evaluated separately for relaxation, wellness and functionality. We focused on two main landscape elements - sound and smell, which are usually less considered by classical landscape architects.

2. Methods

The study was composed of two parts:

In the first stage, an auditory internet questionnaire was formulated (N=193) to identify the preferred elements of landscape. In the second part, experiments conducted in a controlled simulated environment tested the effects of selected elements of landscape, based on the questionnaire results (N=20).

2.1 Interactive internet questionnaire

A new format of interactive pictorial and vocal questionnaire was developed for the study. Pictures were taken from two small gardens, about 50m3, located within the buildings of the faculty of chemistry at our university. The pictures included the elements of gravel, trees, flowers, sitting benches and bushes. We modified one landscape element at a time (using Adobe Photoshop), to examine its isolated effect, while maintaining all other landscape elements constant.

Five elements of landscape were selected for the questionnaire: ground cover, flower colors, bench texture, smells and sounds. Five options were offered for every category, as presented in figure 1. The different sound options were accessed by the internet questionnaire by pressing a button, with options to modify the sound intensity, to stop it and to replay. Smells were presented by pictures of
the relevant plants that produce the specific smells, for better defining the smells. Participants were asked to rank their preferences on a 1-5 scale (from very relaxing and calming to annoying).

Demographic characteristics and information about the past and current housing of respondents (e.g. town, apartment, detached house) and their daily place of stay (e.g. office, outdoor) were accessed.

All data were uploaded into excel files and evaluated statistically using repeated measures ANOVA and ad hoc tests for comparisons. The level of significance was set at P< 0.05.

2.2 Simulated 3D experiments

Experiments were performed at a visualization lab (a 3-D immersive theatre with 7m screen). We built a three-dimensional (3D) model of landscape based on the pocket gardens we used in the questionnaire. We incorporated into the model the selected landscape elements and projected them on a wide screen of the visualization lab.

In this study, we decided to test the effects of sound and smell, each separately, in a controlled stress-induced environment. Sounds were provided by a surround audio system. Smell was produced by fresh herbs kept in sealed boxes, which were opened and squeezed between hands, to spread the natural smell without revealing the sources to the participants. Stress was induced by a PASAT test (Paced Auditory Serial Addition Test) (Tombaugh, 2006), while participants were exposed to 3D pocket garden views. The PASAT test is a common arithmetic test, which is known to induce stress (Tombaugh, 2006). Each subject was tested under 3 experimental conditions of 3D movie (control), 3D movie+ smell, and 3D movie +sound in a random order (crossover design) (Figure 2).

Three sets of measures were used:

- **Functional parameters** – measures of errors and correct answers on the PASAT test.
- **Physiological parameters** – Heart rate, skin sweat (GSR—Galvanic Skin Response – which is inversely proportional to sweating), skin temperature and blood pressure were monitored continuously through miniature sensors attached to the fingers and wrist.
- **Subjective parameters**: Preferences and satisfaction were derived from questionnaires and interviews completed at the end of each experiment.
2.3 Experiment protocol

Each participant received an explanation about the protocol and the PASAT test, signed an informed consent form and was told that he/she could stop the experiment at any time, without explanation. All participants were volunteers.

After explanation, miniature sensors were attached to participants’ hands for continuous recording of physiological parameters. Baseline physiological parameters were taken at the beginning of each experiment, while participants observed a pastoral picture on the screen, and noise intensity was regulated for each person. Each participant received one or more trials of the PASAT to become accustomed to it.

Figure 2 presents the typical protocol of the experiment. Each session lasted about 30 minutes.

Data were analyzed by repeated measures ANOVA at P<0.05 significance level.

Figure 2. A typical protocol of an experiment

3. Results

3.1 Interactive Internet Questionnaire

The survey group

Of 219 respondents, 58% were female. The mean age was 35 years, 63% live in cities, 90% spend most of the day in closed spaces (e.g. office, home, school, etc.), 87% have academic backgrounds and about half have children.

Landscape preferences

The most significant preferences of landscape elements (P<0.05 Tukey test) were:

- **Sound**: Significant preferences were for birds chirping, water sounds and a fountain.
- **Smell**: Significant preferences were for herbal tea mix smells (verbena, mint, lemongrass)
• **Ground cover and texture**: Significant preferences were for a wooden deck and natural grass cover
• **Flower color**: Significant preferences were for mixed-color blossoms
• **Material**: Significant preferences were for a wooden bench

No differences were found in the preferences for any of the categories, according to the gender or age of the respondents.

### 3.2 Simulated 3D experiments

The study included 20 healthy people (ages 23-62 years); 10 male and 10 female. All experiments were conducted at the visualization laboratory, at the same time of the day, under totally isolated and controlled conditions (temperature, noise, illumination).

**Physiological and functional measures.**

No differences were found in the functional parameters of the PASAT scoring under the different experimental conditions. Significant differences were found in heart rate between the control (3D video simulation of urban garden) and the stress induced period (video simulation of urban garden together with PASAT), as can be seen in figure 3. Heart rate increased significantly at each PASAT session and returned to control values after watching the control landscape movie, within 2 minutes.

![Figure 3. Heart rate (beats/min) distribution at the three experimental conditions. Data are presented by a box plot display showing the median, 75% and 25% percentile and data spread. Arrows indicate significance between groups (repeated measures ANOVA P<0.05 Tukey test).](image)

A significant linear negative correlation was found between differences in heart rate (experiment-control) and participant age. No significant differences were found in heart rate between the three experimental conditions (stress, stress+ smell and stress+ sound). No correlation was found between heart rate and gender or age. No significant differences were found in blood pressure, GSR or skin temperature during the three experimental conditions. A borderline statistically significant difference was recorded for the beneficial effect of smell on GSR (sweat), as can be seen in figure 3.
Subjective evaluation

No significant differences were found in participants’ preferences for the different landscape elements for reducing stress. However, as can be seen in figure 4, the participants’ responses varied. During the experimental conditions of smell and sound, 7/20 and 9/20 responded (respectively) that the sound or smell helped them to reduce the stress evoked by the PASAT.

Figure 3 - GSR relative values at the three experimental conditions. A borderline significance was found for the smell group (N=20).

Figure 4 Individual variations in the subjective evaluations for ranking the positive effects of smell and sound on reducing stress.
4. Discussion

This study investigated the isolated effects of two components of landscape (smell and sound) on reducing stress, using functional, subjective and physiological experimental parameters. The first stage of the interactive internet questionnaire helped identify population preferences regarding landscape elements, while the experimental setup enabled testing the elements in a simulated setup. Although no statistically significant results were found, we claim that our experimental setup is a promising and innovative approach for selectively isolating environmental elements and their combination. The setup can be used to develop guidelines for the landscape of small pocket gardens that reduce stress and promote wellness.

The five elements selected herein were considered major components of any landscape. We will explore in the future other elements such as shading, types of trees, lighting, water elements, façades and the interaction between such elements. Expanding the research will enable the formulation of guidelines for planning and designing gardens that may help people relax, improve their functioning, and reduce their stress and distress levels in urban surroundings and at workplaces. This can be expected to reduce obesity and to increase vitality, by conveying a buffering effect on stress (Björk et al., 2008; Lohr, Pearson-Mims and Goodwin, 1996). Particular concern should be directed to preferences of elderly people, as studies have shown beneficial effects of brief exposure to nature on health-related outcomes (Rodiek, 2002).

We believe that small gardens in urban surroundings, in close proximity to peoples’ neighbourhoods and even at workspaces, may improve satisfaction and time spent on physical activity. Small pocket gardens could serve as preferable solutions to the problem of extreme density and lack of public open spaces in modern cities. They could help improve quality of life, foster relaxation and reduce stress levels of people living and working in cities.

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About the Authors:

**Prof Noemi Bitterman**, PhD (Medical Sciences), M.Sc (Industrial Design). Chair of Masters of Industrial Design (MID) with focus on Medical and Social Design, Technion, Research interests: Medical technology and innovation, multimodal design, developing objective methods in design research.

**Ella Simonov**, MSc (Industrial Design), BLA (Landscape architecture) both at the Technion, Israel institute of Technology. Works as a private landscape architect on projects focusing on connection to nature and sustainability, and teaches landscape architecture at the practical engineering program, Technion.