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Outdoor comfort research issues

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Abstract

The paper discusses methodological issues and carrying out problems in outdoor comfort research. It also deals with the relative effects of air temperature, solar radiation and wind speed, as well as with the relationship between thermal sensation and overall comfort sensation, as was found in the outdoor comfort research in Japan. The paper also summarizes several studies going on presently at Tel Aviv University in Israel and presents some of the actual experimental results from these studies.

Keywords: Thermal comfort; Outdoor comfort; Comfort research methodology

1. Introduction

Thermal comfort of persons staying outdoors is one of the factors influencing outdoor activities in streets, plazas, playgrounds, urban parks, etc. The amount and intensity of such activities is affected by the level of the discomfort experienced by the inhabitants when they are exposed to the climatic conditions in these outdoor spaces.

Thus, for example, on a hot summer day the thermal discomfort of people staying outdoors exposed to the sun may discourage them from utilizing available urban parks, depending on the particular combination of the air temperature, the surface temperature of the surrounding areas, the wind speed and the humidity level. The availability of shaded outdoor areas may result in greater utilization of the open space by the public.

In a similar way, in a cold region, a given combination of wind speed and air temperature, or the obstruction of the sun in shaded areas, may discourage people from staying outdoors while the provision of sunny areas protected from the prevailing winds may encourage public activities in that outdoor space.

Thus, minimizing outdoor discomfort may enhance the vitality of the location during periods of extreme temperatures (low in winter and/or high in summer).

The actual levels of the ambient air temperature, solar radiation and wind, in a particular location, can be modified by the design details of the outdoor spaces. Such details may include the provision of shading elements, materials and colors of the surrounding hard surfaces, provision and details of planted surfaces, wind 'breaks' or 'openness' to the wind, etc. Thus, the exposure to, or protection from, solar radiation, the temperatures of the surrounding surfaces, and the local wind speed, can be modified to a large extent by the choice of different design details. Even the local air temperature can be affected to some degree by the outdoor space design details.

In order to evaluate the importance of modifying the outdoor climate in a particular direction by specific design details it would be helpful if the designer would have some means for 'predicting' the effect of a particular change in a climatic element on the comfort of persons staying outdoor.

Almost all of the research done to date on human thermal comfort was conducted under indoor conditions. Specific procedures enabled comparison of results obtained in different studies. For example, the clothing worn by the subjects in different seasons was often the same, regardless of the climatic conditions prevailing outdoor in that location during the testing season. An inherent (although questionable) assumption involved in this procedure is that when a person is staying indoors his subjective reactions to

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temperature, air speed, etc. are independent of the conditions prevailing outdoors.

Research on outdoor comfort involves different conditions and issues, not encountered in studies on indoor comfort. When staying outdoors, people expect variability in the exposure conditions: variation of sun and shade, changes in wind speed, and so on. Pedestrians may be exposed to intense solar radiation and to the winds, factors that modify greatly their response to the temperature and humidity conditions.

Furthermore, people staying outdoors usually wear different clothing in different seasons, clothing that are suitable to the prevailing climate. Therefore, fixed standard clothing is not applicable in outdoor research. In each particular season the subjects should wear clothes which are commonly used in that particular location and season. Thus, in an outdoor comfort study conducted in Japan [2], the subjects wore, in each season, clothes commonly worn by local persons when staying outdoors.

By comparing outdoor comfort studies conducted in different seasons, and/or in regions with different climates, it would be possible to evaluate the effect of changes in the prevailing climatic conditions on the temperature range within which people feel comfortable outdoors, when the subjects are wearing clothing common for outdoor exposure in the given location and season.

The effect of direct exposure to solar radiation is not limited to the thermal sensation. In winter it may produce specific pleasure. On a hot summer day it may produce specific discomfort, beyond the heat sensation. In un-shaded areas pedestrians may also be exposed to surface temperatures much higher in summer and lower in winter than the ambient air temperature.

Outdoors, wind speeds are much higher than the air speeds common indoor. Wind in summer, up to a certain speed, may be specifically pleasant, while in winter it may be specifically annoying. These factors have to be included in evaluating the overall subjective responses to the outdoor environment.

The following section of the paper is a review of an experimental study conducted in Japan in 1994–1995 and of several studies presently conducted in Israel, dealing with outdoor comfort. It describes the research procedures of the studies, presents some selected experimental results and discusses some of the problems encountered in the conduction of the research and in the analysis of the data.

2. The study in Japan—by Noguchi and Givoni

The Fujita Corporation conducted research, monitoring the thermal sensation and overall comfort of subjects staying outdoors in Japan in 1994–1995 [1,2]. The objective of this research was to determine the quantitative effect on the comfort of Japanese persons dressed according to the common practice in the different seasons, of various design features of plazas which can modify the sun and wind exposure conditions during different seasons.

2.1. Research procedure

The research utilized a questionnaire surveys on the subjects' sensory responses and included physical measurement of outdoor climate data.

The subjects' group consisted of six persons, males and females, ranging from the twenties to the fifties. They worked in three pairs, each pair staying in one area for 20 min and moved to a different one. It meant that after 1 h a pair would finish staying in all the three areas: exposed to the sun and undisturbed wind, exposed but with reduced wind and in the shade and undisturbed wind. This procedure was repeated seven times a day. In each 'test' the subjects were asked to sit still in their chairs for 15 min to get used to the condition, and filled in a questionnaire in the remaining 5 min.

The common outdoor clothing in Japan for a given season was selected for each season:

(i) *Spring and autumn*: long-sleeve shirt, jacket and trousers (CLO value = 1.1).
(ii) *Summer*: short-sleeve T-shirt and trousers (CLO value = 0.65).
(iii) *Winter*: long-sleeve shirt, knitted jumper, thick jacket and trousers (CLO value = 1.67).

The questionnaire was mainly concerned with thermal sensation and overall comfort. Thermal sensation is the perception of heat or cold, on a scale of one (very cold) to seven (very hot). The scale of the overall comfort level is from one (very uncomfortable) to seven (very comfortable). Level four is neutral, when one does not feel any thermal discomfort, to correspond with level four of the thermal sensation. The comfort level above five (super comfort) were included so that effects which produce 'pleasure' beyond just comfort, such as the wind in the hot humid summer and the sun in winter, could be identified. This point is further discussed later in the paper.

The experiments were conducted under controlled solar insolation and wind speed in order to understand how these physical factors influence the thermal sensation and the comfort level of Japanese persons staying in outdoor spaces. A grassed open space and an asphalt parking area in a park in Yokohama city were chosen as the sites for the experiments.

The subjects were divided into three groups with different exposure conditions at very small distances between them. The first group was sitting under a large shade tree (TREE). The second group was sitting in a nearby open area exposed to the sun (SUN). The third group was also in the open area but behind a vertical wind break made of transparent polyethylene sheets supported on wood frames (WIND BREAK). The groups were rotated between the three exposure sites so that, on the average, every subject was exposed to the same conditions. The groups were rotated between the three exposure sites every 20 min so that, on the average, every subject was exposed to about the same conditions.