



Development of thermal discernment among visitors: Results from a field study in the Hermitage Amsterdam



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ABSTRACT

Building energy and occupant health concerns have increased the desire for variable, dynamic indoors and hence the interest in comfort of non-uniform and/or transient thermal conditions. An extended thermal comfort field study in the Hermitage Amsterdam museum afforded a unique opportunity to analyse evolving subjective perception of occupants, upon their moving indoors, over the time they spent in the museum. Visitors' responses were grouped depending on how long they had been inside when they filled up the survey. The mean thermal sensation vote of each time group bore a strong correlation with their average time duration. For visitors who had been inside for 20 min or less, the thermal sensation vote had a significant relation with the outdoor temperature but not the indoor temperature. As visitors spent longer indoors, percentage of them feeling warm decreased and percentage of neutral or cool feeling increased. In tandem, the percentage of visitors preferring to be warmer also increased with time. Gender based differences in thermal sensation and preference also had a gradual and logical evolution with time. In an evidence of alliesthesial response, all the visitors inside for 20 min or less, accepted their thermal environment. The overall evidence suggests that visitor's subjective perception of the thermal environment undergoes a distinct evolution during their first hour indoors.

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1. Introduction

Growing concerns for occupant health and energy savings have led to exploration of alternative comfort conditioning strategies, one of which is a more dynamic and variable thermal environment, more in sync with the natural outdoors [1]. Such spaces could provide occupants with positive and pleasurable thermal stimulation, while still contributing to lowering building energy usage. One aspect of dynamic thermal environments is the transition from one set of thermal conditions into another. Researchers have expressed their concerns that the accepted thermal comfort standards may not apply to these circumstances and the population involved [2–4]. Thus, these circumstances have received dedicated attention, but have been mostly limited to laboratory based investigations [5–9]. A small number of studies have also targeted outdoor-indoor transition in such buildings as airport terminals

[10], shopping centres [11], arcades [12] etc. Studies conducted on passengers in airport terminals, an example of transitional population, showed that they were much less concerned with the thermal environment than the people who had to stay there for longer terms, i.e., the staff [10]. However, much attention has not been given to ascertaining, under field conditions, how thermal perception of occupants evolves with time once they have entered a fresh thermal environment. This environment, in most cases, being a building.

The data analysed for the current work was collected during a field study organised at the museum Hermitage Amsterdam. Following renovations to the building in 2009, these surveys were organised to analyse the thermal comfort conditions in the museum, particularly from the visitor's perspective. The survey involved both objective measurements and subjective feedback from visitors. A museum's collection faces threats of deterioration from pollution, relative humidity (RH), temperature, and even the lighting [13], with different categories of collections, requiring different levels of control and micro-climate settings [14]. Several investigations have targeted the indoor environments and energy consumption of museums [15–17]. Concern for safeguarding the

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displayed collections implies that museums go for maintaining stable indoor conditions, with very minimal fluctuations over a day or even over the year.

The irony seems to be that even with tightly maintained indoors, the environment may still be neither satisfactory to the visitors nor satisfactory for the purpose of preserving the collections [18]. Factors that have the most impact on a visitor's overall satisfaction — not just thermal — is regarded to be the “exhibition environment”, consisting of the content and method of the exhibition, visual and locomotor access provided to the visitors, availability of rest areas etc. [19].

The current work focuses specifically on visitors' gradually changing perception of the museum's thermal environment, as they spend longer intervals inside. To this end, their subjective responses in the thermal comfort survey were analysed to bring to fore any underlying trends and differences for visitors who had spent different durations of time indoors.

2. Methodology

Since similar studies in the field environment are few, it was decided to keep the starting hypothesis judiciously generic so as to limit any presumptions during data analysis. The null hypothesis (H_0) we start with is that “The subjective perception of visitors regarding the building's thermal environment undergoes a gradual evolution with duration of time spent indoors”. With this in mind, the visitors were grouped by the length of time past since their entry and the subjective thermal sensations, thermal comfort, and acceptability of these groups were analysed. Since gender and age group based distinctions have been reported by many field studies on thermal comfort [20], any trend in such differences, over the time groups, was also examined.

2.1. Survey location, building, and data collection

As an average visitor to a museum may spend just over an hour inside [19], the surveyed population had individuals who had spent different durations, under an hour to beyond an hour, inside the museum. These circumstances allowed us to analyse and evaluate if the thermal perception of visitors has gradual evolution over the time they spend inside the building. Such an evolution is of course expected as visitors gradually adapt to their new surroundings, but we aimed at ascertaining the nature of this trend for data conducted from a field survey. Unlike typical field surveys where the aim is to allow participants some ‘settling down’ period before involving them in the survey, here the aim was to check on a transitional pattern.

A museum visitor is quite different from an office occupant in at least two major ways. One is that walking to see the exhibits puts a visitor's metabolic rate at a significantly higher value. Second, a visit to the museum is generally at the person's own volition and is a pleasurable hiatus. These aspects would impact the thermal perceptions of the occupant. On the other hand, unlike an office worker, the visitor does not have a consistent experience with the building's indoors and hence can only dress in accordance of the day's outdoor conditions. This may lead to some quick clothing adjustments once the visitor is inside.

2.1.1. The museum

The Hermitage Amsterdam is housed in a seventeenth century building, upon the Amstel, and is a sister museum to the St. Petersburg State Hermitage. Hermitage Amsterdam has no collection of its own and displays collections that are on loan, which change over time. Throughout the thermal comfort survey though, the museum had the same collection on display. The museum

opening hours are from 10 a.m. to 5 p.m., all seven days a week. Anywhere between seven to eleven thousand visitors are welcomed by the museum every week.

The most recent renovation to the building — during 2007–2009 — improved thermal isolation of the building while preserving the historical façade. Insulation was added to the inside of walls. Exhibition areas were given all-air HVAC systems, an apt system for conservation of cultural artefacts [21], while non-exhibition areas were equipped with floor heating, with air curtains being put between transitional spaces and the main exhibition rooms. For storage of thermal energy, an aquifer thermal energy storage system was also installed. The overall system was designed for maintaining indoor conditions at 21 °C and 50% RH, year round.

Some images of the museum indoors, surroundings, and a 3D representation of the interior are presented in Fig. 1. The museum has a central entrance with the left and right wings separated by a garden in the middle (Fig. 1 a). Visitors entering through the central entrance may choose to browse the collections in either wing. In terms of layout, both wings are near identical. For a more detailed description of the museum's layout, the reader may refer to the work from Ref. [22].

2.1.2. Survey duration

Survey period extended from January end, through October 2015, thus covering the end of winter and the bulk of spring and summer. Daily mean temperature during the survey remained between -0.1 and 26.5 °C though most days were between 10 and 20 °C. Surveys were planned during Wednesdays and Thursdays, between noon and 3 p.m., this selection being based upon when the museum expected its largest visitor numbers. This study was conducted in an exhibition room, located in the right wing of the



Fig. 1. Location and interiors of the Hermitage Amsterdam a) The location upon the Amstel (Image ©2016 Google, Map data ©2016 Google) b) Images of displays c) A graphical representation of the interior structure's cross-section.

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