

Investigation of the characteristics of outdoor air movement providing with 'Suzusisa' sensation

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Abstract

'Suzusisa', which is originally a Japanese word, is a pleasant thermal sensation which we may have either in a hot and humid environment with some breeze or in a rather dry environment with radiant cooling sources. This paper describes the relationship between 'suzusisa' sensation and its associated pattern of air velocity obtained under a shaded outdoor space. A female subject participated in the experiment. She did not necessarily feel 'suzusisa' sensation as she is exposed to an environment in which the air movement is strong. She felt 'suzusisa' sensation even with a relatively small air velocity after she was exposed long enough to an environment in which the air movement is still. The normalized air velocity was calculated from the spectra obtained by the Fourier analysis, the amplitude of the normalized air velocity during the period in which the subject had 'suzusisa' sensation is twice that in which she did not. The pattern of the normalized air velocity bringing 'suzusisa' sensation is to increase suddenly and then decrease exponentially.

INTRODUCTION

'Suzusisa' is a pleasant thermal sensation to be sensed under rather unsteady-state conditions; for example, a hot and humid environment with some breeze or a rather dry environment with radiant cooling sources. 'Suzusisa' is originally a Japanese word and has been used in Japan to express a sensation provided by a hot and humid environment [1][2]. According to our everyday experiences, it is very likely for us to have 'cold' sensation in a air-conditioned room, though the objective of space cooling should be to provide a built environment in which one can have comfortably cool or 'suzusisa' sensation [3].

Historically speaking, 'suzusisa' sensation has been a key word in many parts of Japan to express unconsciously the passive cooling effect due to ambient air movement. Therefore, it is important for us to have a better understanding of the characteristics of air velocity, which provide the 'suzusisa' sensation [4].

SUBJECTIVE EXPERIMENT

We set up the outdoor subjective experiment at the campus of Musashi Institute of Technology in Tokyo on the 1st of August and on the 5th of September in 1997. Figure 1 shows a scene of the experiment. In this outdoor environment, the leaves and the branches of tall trees shade most of the solar radiation so that the radiant temperature is lowered to the level of the ambient air temperature. A female student participated in the experiment as a subject and was asked to answer 'suzusisa' sensation while staying in this outdoor environment for thirty minutes. The ambient air temperature, globe temperature, relative humidity, and air velocity were measured and recorded at two-second intervals.

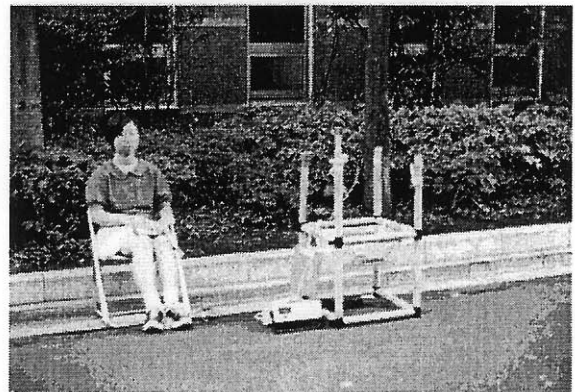


Figure 1. A scene of the subjective experiment on the 5th of September in 1997. A female subject was asked to answer 'suzusisa' as she felt 'suzusisa' sensation. The ambient air temperature, globe temperature, relative humidity, and the air velocity nearly were measured and recorded.

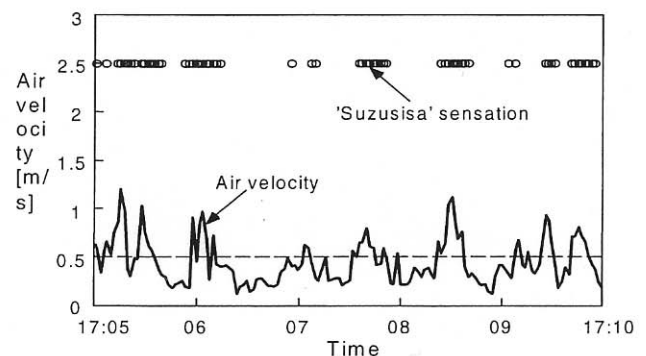


Figure 2. The variation of air velocity with 'suzusisa' votes on the 1st August. The subject felt 'suzusisa' when the air velocity exceeded 0.5 m/s.

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RESULTS AND DISCUSSION

Figure 2 shows an example of the variation of air velocity with 'suzusisa' sensation votes from 17:05 to 17:10 on the first of August. The air velocity varies from 0.2 m/s to 1.2 m/s. The averaged air and mean radiant temperatures are 28.5□ and 30.5□ respectively. The subject answered 'suzusisa' sensation when the air velocity exceeds 0.5 m/s, which is the average of the air velocity in this period.

Figure 3 shows the percentage of the 'suzusisa' sensation votes at a certain air velocity. On the first of August, the subject felt 'suzusisa' sensation against lower air velocity, 0.5 m/s to 1.5 m/s, while on the 5th of September, she felt 'suzusisa' against higher air velocity from 2.0 m/s to 3.0 m/s. The averaged air velocity of the 5th of September is larger than that of the first of August. This implies that the subject does not necessarily feel 'suzusisa' sensation even if she is exposed to an environment in which the air velocity is high.

Figure 4 shows the air velocity against which the subject first felt 'suzusisa' sensation after a period of exposure to the environment in which she felt no 'suzusisa' sensation. It is possible to feel 'suzusisa' sensation even with a relatively low air velocity after she is exposed long enough to an environment in which no 'suzusisa' was sensed, namely a continuous low-air-velocity condition. The length of the period in which the subject felt no 'suzusisa' sensation is shorter than 30 seconds. This length of the period could be consistent with the period for the evaporation of the sweat from the skin surface to the environment.

We made Fourier analysis in terms of air velocity to make clear the characteristics of the air movement, which provide with 'suzusisa' sensation. We used 32 samples of the air velocity variations, each period of which is sixteen seconds. A half of these samples are for 'suzusisa' sensation and the rest for no 'suzusisa' sensation. The spectra of the air velocity during the periods in which she had 'suzusisa' sensation is larger than that during the periods in which she felt no 'suzusisa' sensation.

We calculated the normalized air velocity from the spectra to reveal a pattern of air velocity, which provides the subject with 'suzusisa' sensation. Figure 5 shows the normalized air velocities, which bring 'suzusisa' sensation and no 'suzusisa' sensation. The amplitude of the normalized air velocity bringing 'suzusisa' is twice larger than that bringing no 'suzusisa'. The overall pattern of the normalized air velocity bringing 'suzusisa' sensation is to increase suddenly and decrease exponentially.

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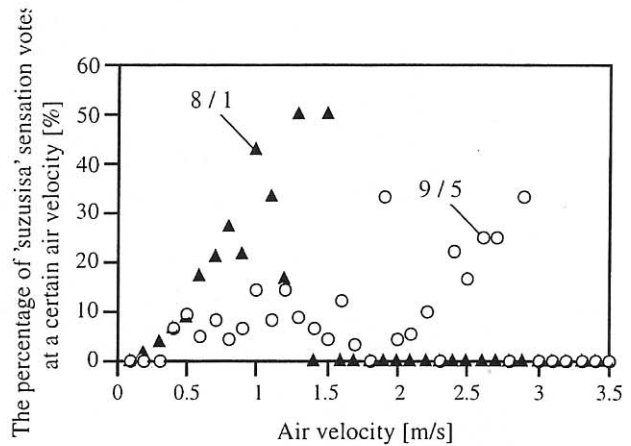


Figure 3. The percentage of the 'suzusisa' sensation vote at a certain air velocity on the first of August and on the 5th of September.

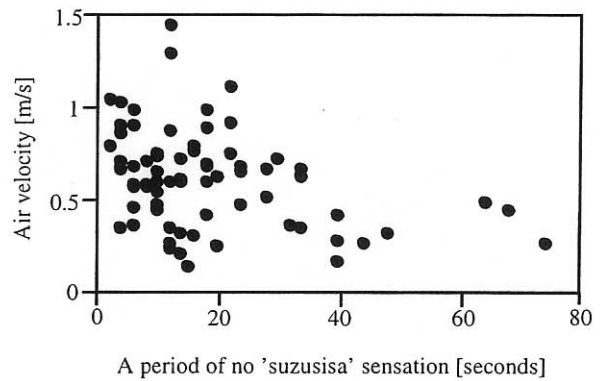


Figure 4. The air velocity against which the subject first felt 'suzusisa' sensation after a period of exposure to the environment in which she felt no 'suzusisa' sensation.

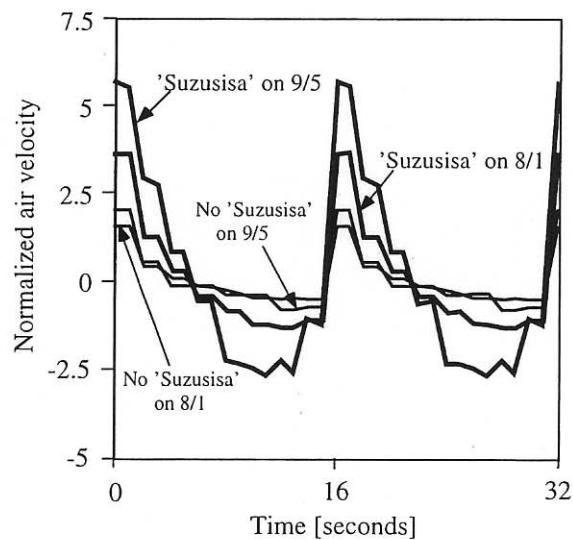


Figure 5. The normalized air velocity which brings 'suzusisa' sensation and no 'suzusisa' sensation on the first of August and on the 5th of September.