

International symposium about thermal comfort of clothing and smart textile in Nara, Japan  
held by “the Japan Research Association for Textile End-Uses” at September 6,7 of 2019.

## Program: Comfort workshop

### Risk of heatstroke under the hot environment and the heatstroke prevention by optimization of design of clothing

#### Abstract

The theme of the comfort workshop is “risk of heatstroke under the hot environment and the heatstroke prevention by optimization of design of clothing”. Tokyo Olympic Games and Paralympics will be held in 2020. Risk of heatstroke will most likely increase among the players and the audience in the hot and humid environment. Therefore, we should understand a mechanism of heatstroke occurrence under the hot environment. It is essential to grasp a signal of heatstroke according to the individual situation as soon as possible and build the prevention system and feedback. So we invite the famous, domestic and foreign researchers, in the fields of an ergonomics, fiber engineering, physiology and so on and we will hold the workshop to learn the mechanism of heatstroke occurrence under the hot environment and the heatstroke prevention by optimization of design of clothing. It's expected that the hint which applies a smart textile to a heat exhaustion prevention system is found in the workshop.

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9:30~9:35 **Opening greeting**

9:40~10:20 Prof. Dr. **Yoshimitsu Inoue** (Osaka International University,  
Japan)

#### “Aging and sweating function”

Considering global warming, the increasing population of elderly, and the susceptibility of the elderly to heat illness, the incidence of heat illness in the elderly during daily life in warm weather is expected to increase in future. The main effector response for dissipating heat when exposed to environmental heat is sweating. In order to provide a rational basis for preventive strategies to reduce the incidence of heat illness among the elderly, it is important to understand age-related impairment of the sweating function. Based on our studies of the heat-, exercise- acetylcholine-induced sweating responses, will review 1) how the sweating function declines with aging, 2) sex differences in the age-related decline, 3) primary mechanisms underlying the aging- and sex-related changes, and discuss 4) how the accumulated knowledge can be applied to the development of summer-wear and sportswear for the elderly.

Key word: Sweating, Elderly, Sex difference



## Keynote speech

10:20~11:20 Prof. Dr. **George Havenith**

(Environmental Ergonomics Research Centre, Loughborough University, UK)

### **“Physiological Responses of the human body and their interaction with perception and thermal comfort of clothing”**

Human evolution delivered an organism designed for life in warm environments. Humans have developed further, mainly by their behavioural adaptations. The most important one being the use of clothing and shelter. Clothing is worn for protection, but also as part of a social code. In the heat, the latter can increase the body's strain, rather than reduce it, as it does in the cold. In that way, clothing can both decrease or increase our comfort.

In order to understand the interaction of clothing and the body, we need to understand the perceptual mechanisms. For temperature, these are straightforward, but e.g. for wetness perception these are complex.

In this presentation an overview will be presented of our work on mapping of the human body in terms of physiological responses, and of our work in relation to the perception of temperature and moisture in the interaction with clothing.

Key word: Moisture Perception, heat stress, Discomfort



Prof. Dr. George Havenith

11:30~12:00 Dr. **Yasunori Kotani**

(School of Environment and Society, Tokyo Institute of Technology)

### **“Brain networks connecting body and mind”**

Recent brain science has revealed that there are three large scale networks inside the human brain: default mode network, central executive network, and salience network. In these three networks, the default mode network is activated during “OFF” state like being relaxed and thinking involuntary about past, future,

and people related to oneself. The central executive network is activated in “ON” state that needs higher cognitive functions including attentional control, decision making, and problem solving. On the other hand, the salience network switches between the default mode network (ON state) and the central executive network (OFF state) based on information from the body.

These findings suggest that the peripheral bodily state affects functions of brain networks, and that the bodily state is a more important factor for human cognitive functions than we thought.

In our talk, we introduce mechanisms of interaction between body and brain (mind) in terms of the triple network model. We also discuss the possibility of smart textile that affects human mind by manipulating bodily state.

Key word: brain network, saliency, insular cortex



Dr. Yasunori Kotani

12:00~12:30 **Lunch time**

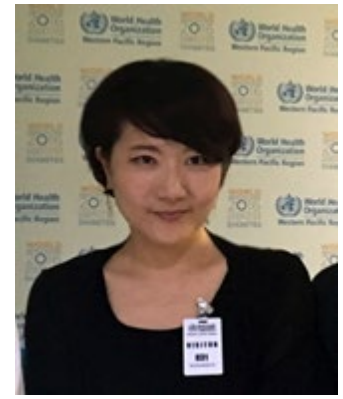
12:30~14:00 **Poster session**

14:00~14:30 Dr. **Joo-Young Lee** (Seoul National University)

**“Thermal effects of graphene and its application to clothing”**

Graphene is a material with unique properties including higher electric and thermal conductivity, flexibility, and strength than other materials in the world. We have investigated the thermal properties of graphene to apply it to clothing in three ways. First, we tested the thermal dynamics of microwave reduced graphene oxide (MW-rGO) coated polyester fabric. Second, thermal conductive characteristics of copper-graphene composite films were evaluated using a human skin analogue (the pig skin). Third, we investigated the effects of integrating graphene heaters into cold protective clothing under cold stress on physiological and psychological responses through human wear trials. As a result, the thermal effects of graphene film and reduced graphene oxide were dependent on air temperature and surface temperature, but accumulated surface heat was greater for graphene film than copper film. An intermittent heating protocol using graphene heaters conserved electricity while maintaining thermal comfort for wearers when compared to a continuous heating protocol. These results suggest the possible application of graphene to body temperature regulating clothing to mitigate heat or cold stress.

Key word: Graphene, Heating, Thermal conductivity, Skin temperature, Thermal comfort



Dr. Joo-Young Lee

14:30~15:00 Dr. **Tatsuro Amano** (Niigata University)

**“Regulation and adaptation of human sweating”**

Sweating is a vital physiological pathway to dissipate heat from the body and the magnitude of its ability (or capacity) may have an impact to reduce heat strain and possibly influences human performance during exercise including occupational situation in the heat. It is traditionally well known that habitual exercise training and heat acclimation improve sweating response during exercise or heat stress while its precise mechanism was still remained unknown. In this presentation it will be presented some basic insights for regulating sweating during exercise and heat stress and will introduce our recent works associated with the underlying mechanisms of human sweating adaptation to exercise training. Especially it will present our new findings associated with contributions of non-cholinergic neural mechanism including adrenergic pathway for human sweating during exercise. The presentation will generally focus on physiological insights into understanding sweating control in humans while it is welcome to discuss potential future applications for clothing, smart textile, human comfort, and sports.

Key word: Eccrine sweat gland, exercise training, sympathetic nerves



Dr. Tatsuro Amano

15:00~16:00 Prof. Dr. **Jintu Fan** (Hong Kong Polytechnic University)

**“Thermal Regulatory Clothing for Personal Thermal Management”**

Human beings are homeothermic, which means their body temperature should be maintained within a very narrow range. This can be achieved to some extent by human body’s own thermoregulation, but its ability is very limited so in most circumstances, clothing and/or shelter are essential for survival. It has been shown indoor HVAC systems (heating, ventilation and air conditioning system) consume about 13% of total energy consumption. Provided personal thermal management can enable the indoor HVAC set-point to be broaden by 4°F (2.2°C) on both side with compromising thermal comfort, we can save over 15% HVAC energy consumption or about 2% of total energy consumption.

Clothing, as a portable environment, is ideal for personal thermal management. Heating or heat conservation using clothing can be achieved by adding insulation or heating elements into clothing. Comparatively, cooling in clothing is more challenging. Effective cooling garments will not only save huge energy consumption in indoor space cooling, but also significantly improve the quality of life in outdoor environments.

This presentation will examine the recent developments in smart textiles and clothing as well as wearable electronics for both passive and active personal thermal management.

Key word: Thermoregulation, Personal Thermal Management, Energy Saving, Thermal Comfort, Smart Clothing

16:00~16:10 Rest (Poster session)

16:10~16:40 Dr. **Shingo Tsukada**

(Basic Research Laboratories Nippon Telegraph and Telephone Corporation)

**“Electro conductive polymer coated nanofiber textile electrodes for biomedical signal recordings”**

Biomedical signal recordings such as electrocardiography (ECG), electromyography (EMG) and electroencephalography (EEG) are important for medicine and worker’s safety in highly aged society. However, conventional medical electrodes which were made with electrolyte gel and adhesive tapes, often elicit skin irritation and discomfort to patients for long term (Holter) ECG recordings. In order to measure precise bioelectrical signals without stress, we developed the textile electrodes “hitoe” using the electro conductive polymer, PEDOT - PSS (poly(3,4-ethylenedioxythiophene) polystyrene sulfonate) coated polyester nanofiber textile (fiber diameter 700nm). The textile electrode pad has

flexibility, biocompatibility, washing durability, soft texture as normal garments. The underwear which has “hitoe” electrode pads inside of the stretch shirt (for male) or brassiere (for female) in the cardiac electric field of chest were able to record the same waveforms as conventional medical electrodes. Skin irritation has not been induced by “hitoe” during 7-90 days ECG measurements. Because of its strong hydrophilicity, “hitoe” kept epidermal moisture and its electro conductivity stably in variety of mental, physical and environmental situations, which result in noise less ECG data. The textile electrodes are useful tool for human big data analysis in medical and none medical field.

Key word: nanofiber, wearable electrode, electro conductive polymer

16:40~16:55 **Panel discussion**

16:55~17:00 **Closing greeting**



Prof. Dr. Jintu Fan



Dr. Shingo Tsukada