

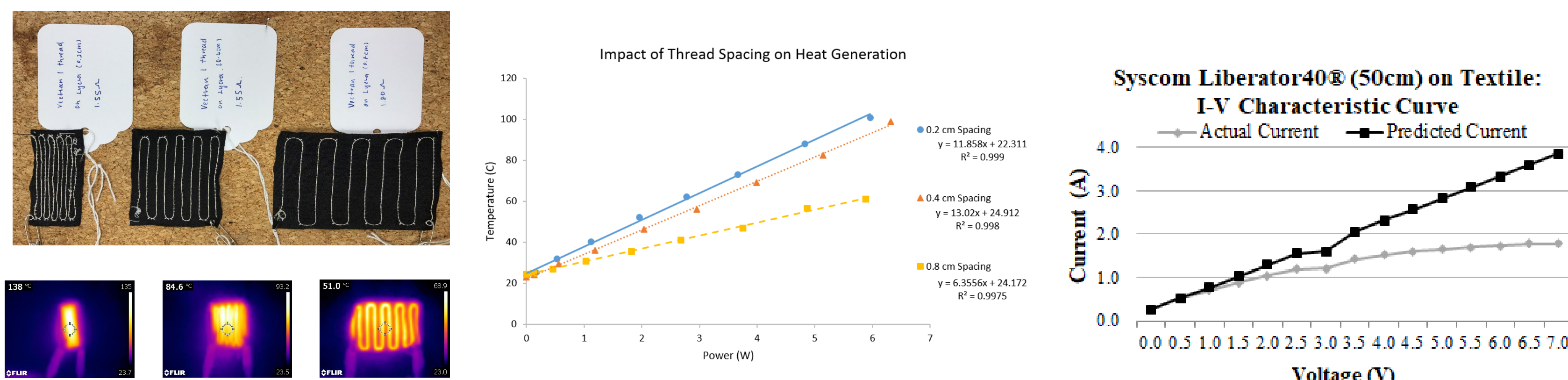
Breakthrough: Toward personal microclimate: Sustainable heating through smart clothing

Lucy Dunne, University of Minnesota
wtl.umn.edu

Project Objective: Reduce energy expenditure on indoor environments (particularly unused/underused environments) while facilitating customized thermal control for individual users by supplementing ambient heat with on-body heated garment systems. Our priority is maintaining thermal comfort in cooler environments for everyday contexts.

Developing textile-based thermal actuators

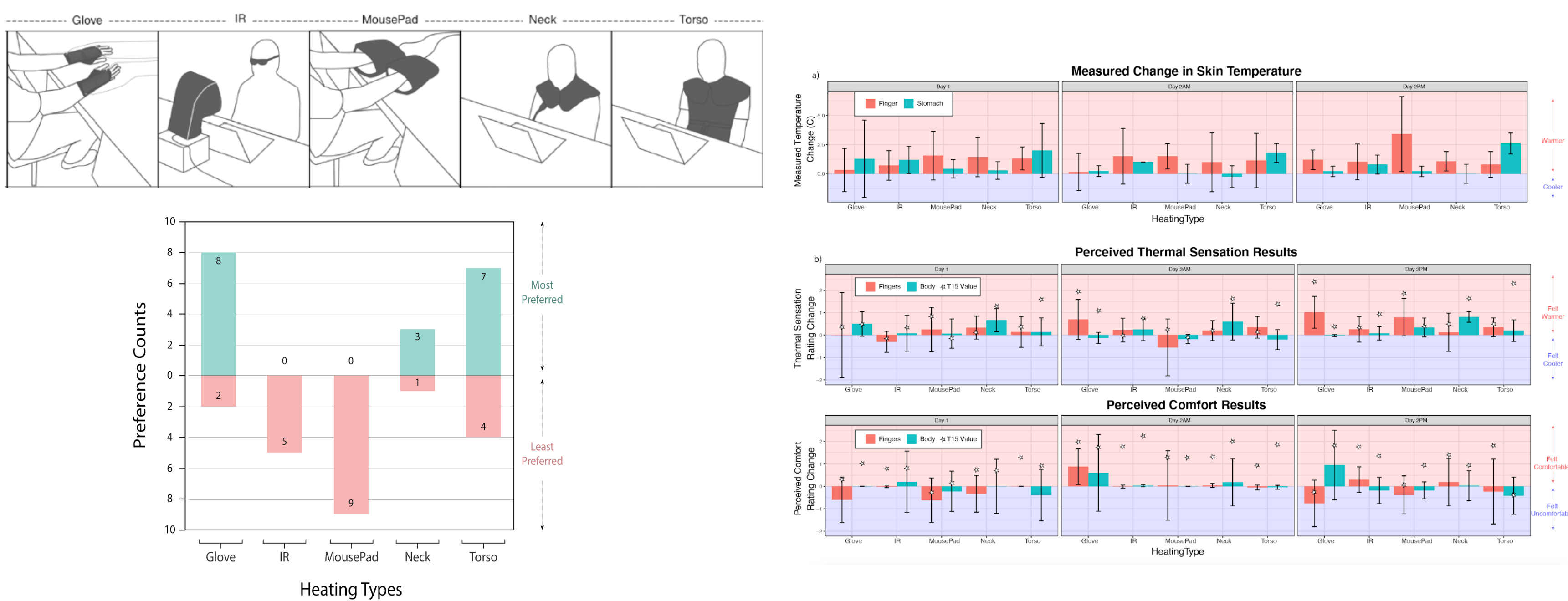
Stitched silver-coated Vectran thread allows customized actuator location and density



Foo, Esther, et al. "Toward the development of customizable textile-integrated thermal actuators." *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*. 2017.

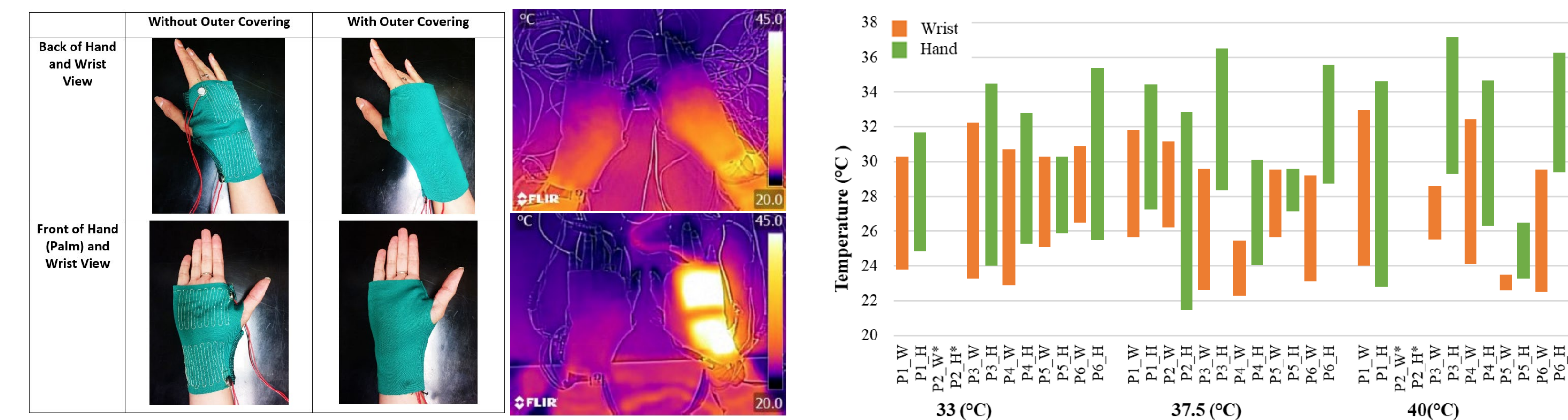
Understanding Mediated Thermoneutral Experience

Comparative assessment of on-body heating strategies in field environments



Understanding Mediated Thermoneutral Physiology

Thermal chamber evaluation of hand-heating and fingertip blood flow



Gagliardi, Nika, et al. "Design of a Stitched Textile-Based Thermal Actuator Garment to Attenuate Peripheral Microclimate Experience." *Frontiers in Biomedical Devices*. Vol. 40789. American Society of Mechanical Engineers, 2018.

Broader Impacts

On Society: Prior work has measured up to 22.7% of residential climate control energy is wasted on heating un/underused spaces¹, occupancy-based controls could save up to 67%². Further, human performance is improved with thermal comfort.

On Education and Outreach: Interdisciplinary project team from ~8 different disciplinary backgrounds, 60% are women. Project outcomes integrated into extension programs with underrepresented high school students. Project has supported 10 REU students and two UROP projects.

On the Discipline: Closed-loop cyber-physical systems that involve interaction with human physiology and textile-based systems introduce new challenges for CPS. Better understanding of mediated physiology in the thermoneutral zone will allow development of more successful intervention technologies and control models.

¹Meyers, Robert J., Eric D. Williams, and H. Scott Matthews. "Scoping the potential of monitoring and control technologies to reduce energy use in homes." *Energy and Buildings* 42.5 (2010): 563-569.
²Zhang, Jian, et al. Energy savings for occupancy-based control (OBC) of variable-air-volume (VAV) systems. No. PNNL-22072. Pacific Northwest National Lab.(PNNL), Richland, WA (United States), 2013.